United Nations
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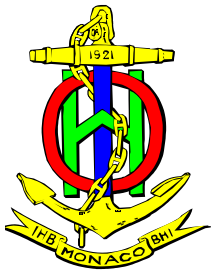
Commission



User Guide to the GEBCO Digital Atlas and its data sets

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Natural Environment Research Council

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The British Oceanographic Data Centre is responsible for updating, maintaining, quality controlling and publishing the GEBCO Digital Atlas. This work is funded by the UK Natural Environment Research Council.

The continued development of the GEBCO Digital Atlas would not be possible without the untiring efforts of the countless marine scientists and hydrographers who continue to collect echo-sounding measurements across the world's oceans. Likewise, it also depends on the efforts of the many hydrographic offices, marine laboratories, government agencies and university departments who assemble, maintain and make these data available for use by GEBCO. But most of all, it depends on those individuals responsible for compiling and interpreting these data into bathymetric charts and grids - their names are to be found in the chart descriptions presented in Annexes K to N.

Terms of use and attribution

Head Department of Navigation and Oceanography, St. Petersburg, for the First Edition of the International Bathymetric Chart of the Mediterranean;

International Hydrographic Bureau, Monaco, for the IHO/IOC Gazetteer of Geographic Names of Undersea Features;

UK Hydrographic Office, Taunton for the Third Edition Echo-Sounding Correction Tables;

New Zealand National Institute of Water and Atmospheric Research for the Bathymetric Chart of the New Zealand Region;

Alfred Wegener Institute for Polar and Marine Research, Bremerhaven for the Bathymetric Chart of the Weddell Sea;

Service Hydrographique et Oceanographique de la Marine, Paris for IBCEA Sheets 1.06, 1.08, 1.09, 1.10, 1.11 and 1.12;

Instituto Hidrografico, Lisbon for IBCEA Sheet 1.01;

Instituto Nacional de Estadística, Geografía e Informática, Mexico for IBCCA published sheets.

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If the bathymetry is being reproduced in its original form for a specific region then the acknowledgement should include reference to the scientific co-ordinators responsible for compiling the original contours, for example: 'The bathymetry is reproduced from GEBCO Sheet G.08 compiled by R.L. Fisher of the Scripps Institution of Oceanography and extracted from the GEBCO Digital Atlas published by the British Oceanographic Data Centre on behalf of the IOC and IHO, 2003'.

Correct citation for this publication: IOC, IHO, and BODC, 2003 , "Centenary Edition of the GEBCO Digital Atlas", published on CDROM on behalf of the Intergovernmental Oceanographic Commission and the International Hydrographic Organization as part of the General Bathymetric Chart of the Oceans; British Oceanographic Data Centre, Liverpool.

DISCLAIMER

Information in the GEBCO Digital Atlas has been obtained from sources believed to be reliable but its accuracy and completeness cannot be guaranteed. Whilst every effort has been made to ensure its reliability within the limits of present knowledge, no responsibility can be accepted by those involved in its compilation or publication for any consequential loss or damage arising from its use.

GEBCO is essentially a deep ocean product and does not include detailed bathymetry for shallow shelf waters. Even to the present day, most areas of the world's oceans have not been fully surveyed and, for the most part, bathymetric mapping is an interpretation based on random tracklines of data from many different sources. The quality and coverage of data from these sources is highly variable. Although the GEBCO_2014 Grid and GEBCO One Minute Grid are presented latitude and longitude intervals of 30 arc-seconds and one arc-minute respectively, this does not imply that knowledge is available on sea floor depth at this resolution - the depth in most 30 arc-second squares of the world's oceans has yet to be measured.

THE GEBCO DIGITAL ATLAS IS NOT TO BE USED FOR NAVIGATION OR FOR ANY OTHER PURPOSE INVOLVING SAFETY AT SEA

Update History

Since its publication in 2003 the following updates and new data sets have been released for use with the GEBCO Digital Atlas and its Software Interface. Please note that the GEBCO_08 Grid has been superseded by the GEBCO_2014 Grid and is no longer included in the GEBCO Digital Atlas.

December 2014

Release of the GEBCO_2014 global bathymetric grid.

This is an updated version of the GEBCO_08 Grid and includes the following new data sets

- Southern Ocean (south of 60°S): International Bathymetric Chart of the Southern Ocean (IBCSO) V1
- Arctic Ocean (north of 64°N): International Bathymetric Chart of the Arctic Ocean (IBCAO) V3
- Waters around Australia: Australian Bathymetry and Topography Grid, June 2009
- European Marine Observation and Data Network (EMODnet), 2013 data set.
- Baltic Sea Bathymetry Database.
- Japan Coast Guard Grid for the North Western Pacific Ocean region.
- Bathymetry data for all ocean regions: From the Global Multi-Resolution Topography (GMRT) synthesis, provided by the Lamont-Doherty Earth Observatory at Columbia University
- South China Sea region: update based on sounding data extracted from Electronic Navigation Charts (ENC), provided by the East Asia Hydrographic Commission.
- Waters off Chile, update based on ENC sounding data.
- North American Great Lakes: Bathymetric grids provided by the US National Oceanic and Atmospheric Administration (NOAA), National Geophysical Data Center (NGDC), U.S
- North Atlantic Ocean, Gulf of Cadiz region: Bathymetric compilation produced under the European Science Foundation (ESF) EuroMargins SWIM project “Earthquake and Tsunami hazards of active faults at the South West Iberian Margin: deep structure, high-resolution imaging and paleoseismic signature”
- Indian Ocean, region off Sumatra: Bathymetric survey carried out by HMS Scott in 2005
- Waters off the West Coast of Africa: update based on bathymetry data from Olex
- Northwest European Continental Shelf area: update based on bathymetry data from Olex
- South Pacific Ocean, Coral Sea region, update to correct an error in the GEBCO grid due to the inclusion of an erroneous island (“Sandy Island”)

Further information can be found in Annex N.

October 2010

Release of version 20100927 of the GEBCO_08 Grid to include:

- Bathymetric grid for the Black Sea region provided by Dr. John Hall, Geological Survey of Israel (retired), based on bathymetric soundings digitised from Russian hydrographic charts.

- Bathymetric grid for the Caspian Sea region provided by Dr. John Hall, Geological Survey of Israel (retired), based on bathymetric soundings digitised from Russian hydrographic charts.

- Bathymetric grid for the Weddell Sea provided by the Alfred Wegener Institute for Polar and Marine Research (AWI). The grid is based on the bathymetric Chart of the Weddell Sea (BCWS).

November 2009

Release of version 20091120 of the GEBCO_08 Grid to include version 2.23 of the International Bathymetric Chart of the Arctic Ocean (IBCAO) north of 64°N.

Release of the GEBCO_08 Source Identifier (SID) Grid. This data set identifies which grid cells in the GEBCO_08 Grid are based on bathymetric soundings or bathymetric depth values from grids and which cells contain predicted depth values. Further information about the format of the data set is given in Annex N.

May 2009

Version 2.12 of the GEBCO Digital Atlas Software Interface.

January 2009

Release of the GEBCO_08 Grid – a global bathymetric grid at 30 arc-second intervals.

November 2008

Version 2.0 of the GEBCO One Minute Grid

July 2006

Version 2.0 of the GDA Software Interface.

Useful Websites

GEBCO home page
http://www.gebco.net

GEBCO Digital Atlas Software updates
http://www.bodc.ac.uk/help_and_hints/software_updates/gebco.html

GEBCO data set errata
http://www.bodc.ac.uk/help_and_hints/errata/gebco/

SCAR Coastline and Antarctic Digital Database
http://www.add.scar.org

World Vector Shoreline
http://shoreline.noaa.gov/data/datasheets/wvs.html

International Bathymetric Chart of the Arctic Ocean (IBCAO)
http://www.ibcao.org

International Bathymetric Chart of the Southern Ocean (IBCSO)
http://www.ibcso.org/

International Bathymetric Chart of the Mediterranean (IBCM)
http://www.ngdc.noaa.gov/mgg/ibcm/

International Bathymetric Chart of the Caribbean Sea & Gulf of Mexico (IBCCA)
http://www.ngdc.noaa.gov/mgg/ibcca/

International Bathymetric Chart of the Central Eastern Atlantic (IBCEA)
http://www.ngdc.noaa.gov/mgg/ibcea/

IGBP Global Land One-kilometer Base Elevation (GLOBE) Project
http://www.ngdc.noaa.gov/mgg/topo/globe.html

IHO Data Centre for Digital Bathymetry
http://www.ngdc.noaa.gov/mgg/bathymetry/iho.html

GEODAS World Geophysics Database
http://www.ngdc.noaa.gov/mgg/geodas/

Names of Undersea Features (inc. IHO/IOC Gazetteer)
http://www.gebco.net/data_and_products/undersea_feature_names/

Generic Mapping Tools (GMT) software
http://gmt.soest.hawaii.edu/

netCDF format
http://www.unidata.ucar.edu/packages/netcdf/

ESRI Shapefile format
http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf

Contents

GEBCO DIGITAL ATLAS

1.0 INTRODUCTION

The First Edition of the General Bathymetric Chart of the Oceans (GEBCO), issued in 1905, established a tradition for publishing GEBCO as a series of printed sheets covering the globe at a scale of 1:10 million. This approach continued through to the publication of a Fifth Edition of GEBCO by the Canadian Hydrographic Service in the years between 1978 and 1982. For information on the historical background to GEBCO and on the production of the Fifth Edition please refer to Annexes A and B.

In 1983, the Joint IOC/IHO Guiding Committee for GEBCO decided that the printed sheets of the Fifth Edition should be digitised. This proved to be a major task and took the best part of ten years to complete (see Annex C). The bulk of the work was carried out by the Bureau Gravimétrique International in Toulouse and the British Oceanographic Data Centre (BODC). The resultant data set, which covered all the bathymetric contours, coastlines and trackline control information depicted on the Fifth Edition sheets, provided the basis for establishing what is now called the GEBCO Digital Atlas (GDA).

In 1989, the GEBCO Guiding Committee decided that the GDA should form the base from which future printed editions of GEBCO would be generated. However, rather than being geared towards the printing schedules of such future editions, the updating of the GEBCO through the GDA would be a continual process and the GDA would be published regularly as a product in its own right. Without the scale constraints of the printed chart, it was envisaged that improved bathymetric compilations would be merged into GEBCO at scales ranging from 1:10 million up to 1:250,000 depending on the density of echo-sounding coverage. This would be achieved by 'stitching in' so as to maintain the seamless nature of the data set at least for the basic GEBCO contours at 200m, 500m and at 500m intervals thereafter.

The First Release of the GDA was published by BODC in March 1994 on a single CDROM. It included the digitised bathymetric contours, coastlines and trackline control from the GEBCO Fifth Edition; a digitised version of the International Bathymetric Chart of the Mediterranean (IBCM); a high resolution, digital, global coastline; a digital gazetteer of undersea feature names and a trackline inventory of the echo-sounding data held at the IHO Data Centre for Digital Bathymetry. A Second Release was published by BODC in March 1997 which included new bathymetric charts for the southern Indian Ocean, the Weddell Sea and the north-east Atlantic off the British Isles, and an improved coastline for Antarctica.

The Centenary Edition of the GDA was released to coincide with the hundredth anniversary of the offer made in April 1903 by HSH Prince Albert I of Monaco to fund and organise the production of a series of charts to be called the “General Bathymetric Chart of the Oceans”.

The GEBCO Digital Atlas includes a Microsoft Windows software interface that enables users to view the GEBCO bathymetry in a variety of forms and projections and to select and download contour vectors and gridded data for use in their own applications.

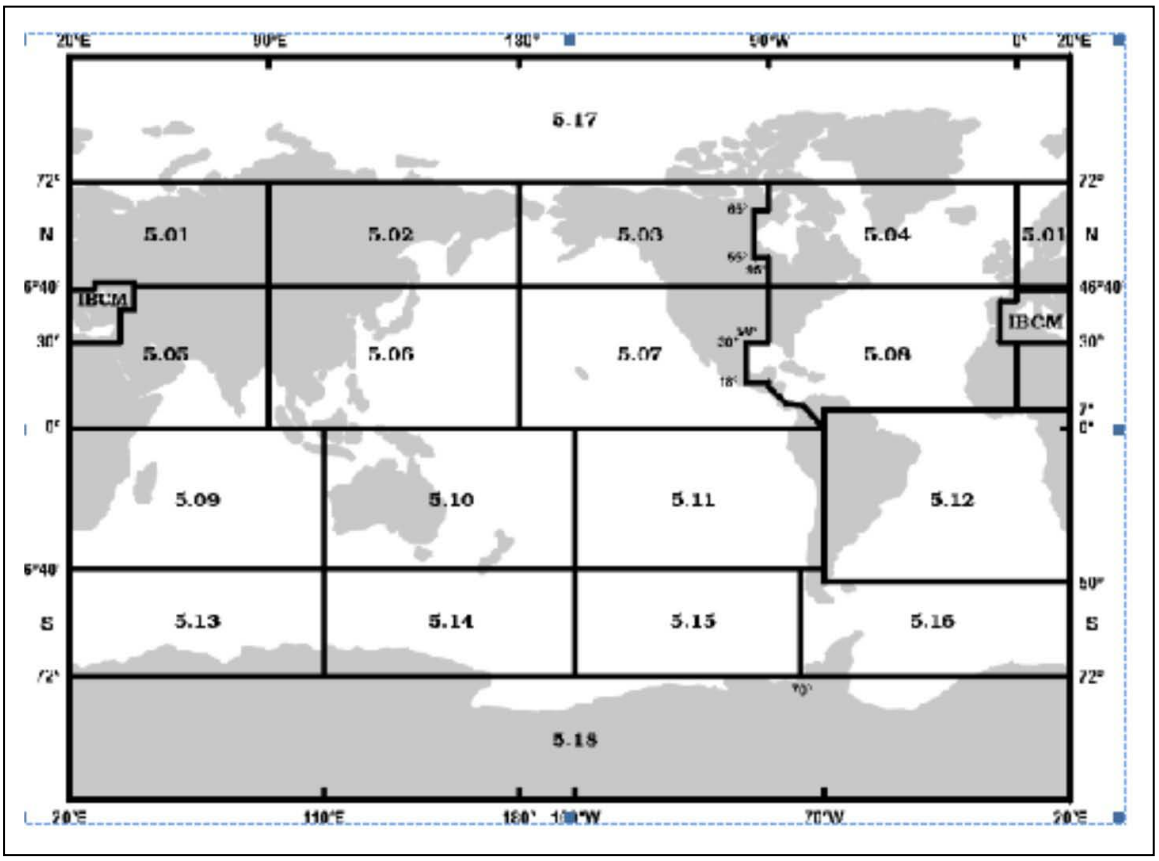
One important aspect of GEBCO, is the inclusion of trackline information highlighting the coverage of data used in its compilation. This is intended to act as a continual reminder to users that the world’s oceans have not been systematically surveyed and that, for virtually all areas of the oceans, the mapping is based on the interpretation of random tracklines of data from a multitude of sources and with highly variable data quality and coverage.

The GDA has been updated in November 2008; May and November 2009; October 2010 and December 2014 to include new versions of the software interface and data sets. Further details can be found in the 'update history' section of this document.

The latest versions of GEBCO's grids are available via the web:

http://www.bodc.ac.uk/data/online_delivery/gebco/.

Figure 1: Geographic coverage of sheet areas digitised from the GEBCO Fifth Edition to form the First Release of the GEBCO Digital Atlas issued in 1994



2.0 CONTENTS

The GEBCO Digital Atlas (GDA) is published as a pair of discs (discs 1 and 2) and contains three main components viz a set of User Guides, the GDA data sets and a GDA Software Interface.

User Guides are provided:

i) User Guide to the GDA and its data sets (this volume) in file Manual.pdf on disc 1
ii) User Guide to the GEBCO One Minute Grid in file GRID/gridone.pdf on disc 1
iii) User Guide to the GEBCO_2014 Grid in file GRID/gebco_2014.pdf
iv) User Guide to the GDA Software Interface in file help.pdf on disc 1

All are accessible using Adobe Acobat Reader either directly or through the 'help' menu of the GDA Software Interface

The following data sets are incorporated in this release:

a) the digitised bathymetric contours, coastlines, and trackline control of the October 2002 version of the GEBCO Digital Atlas. Based primarily on the digitised GEBCO Fifth Edition, it also includes completely new bathymetry for the Arctic and Indian Oceans as well as significant updates for areas of the North Atlantic, the Weddell Sea and the area around New Zealand. (A binary version is stored on disc 1 for user-selected display/export via the GDA Software Interface, while an ASCII version is stored on disc 2 for users requiring direct access).

b) Gridded bathymetric data sets: The GEBCO_2014 Grid - a global 30 arc-second interval terrain model released in December 2014. This is an updated version of the GEBCO_08 Grid. Further details can be found in Annex N of this document.

   GEBCO One Minute Bathymetric Grid. Based primarily on the bathymetric contours of the October 2002 version of the GDA, it also incorporates the IGBP GLOBE one-minute grid for land elevations. Further details about this release can be found in Annex M

   These data sets are stored on disc 1 in netCDF format, both for user-selected display/export via the GDA Software Interface and for direct access by the user.

c) the digitised bathymetric contours and coastlines from the First Edition of the International Bathymetric Chart of the Mediterranean. (A binary version is stored on disc 1 for user-selected display/export via the GDA Software Interface, while an ASCII version is stored on disc 2 for users requiring direct access).

d) a set of digital global coastlines from the World Vector Shoreline at a range of scales from 1:43 million up to 1:250,000 or better for coastlines north of 60°S. (A binary version is stored on disc 1 for user-selected display/export via the GDA Software Interface; a direct access version is not available to the user)).

e) four versions of the SCAR Coastline of Antarctica (Version 3.0) at a range of scales from 1:10 million up to 1:250,000 (replacing the World Vector Shoreline south of 60°S). (A binary version is stored on disc 1 for user-selected display/export via the GDA Software Interface, while an ASCII version is stored on disc 2 for users requiring direct access).

f) a trackline inventory of the digital echo-sounding data held at the IHO Data Centre for Digital Bathymetry as of June 2002.(A binary version is stored on disc 1 for user-selected display/export via the GDA Software Interface, while an ASCII version is stored on disc 2 for users requiring direct access).

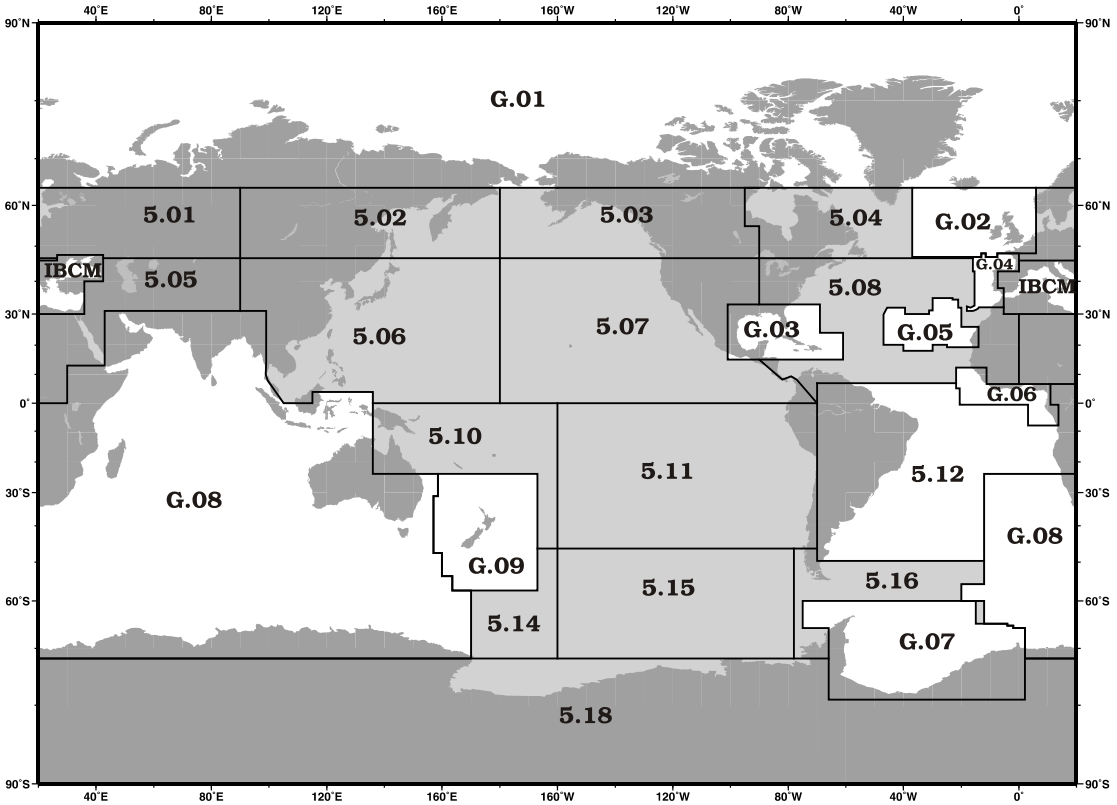
g) a digital set of geographically referenced feature names including the IHO/IOC Gazetteer of Geographical Names of Undersea Features, a list of the ports/cities and Antarctic islands portrayed on the printed sheets of the GEBCO Fifth Edition, a list of Antarctic stations and a specially prepared list of oceanic islands. (An internal version is stored on disc 1 for interactive display and querying via the GDA Software Interface. This information is not directly accessible to the end user).

h) a digital version of the Third Edition of the IHO Echo-Sounding Correction Tables (stored on disc 1 both for direct access by the end user and for use within the GDA Software Interface).

Comprehensive documentation on the above data sets is contained in the Annexes of this User Guide. In particular, detailed information is provided on each of the charts used in the compilation of the GEBCO contours (Annexes K and L). This information includes the authorship and specification of each chart, and information on the methods by which each chart was compiled, including the data sources used.

Annexes M and N provide information on the development of GEBCO's gridded bathymetric data sets.

Figure 2: Geographic coverage of sheet areas digitised to form the Centenary Edition of the GEBCO Digital Atlas *(White areas show sheets compiled at scales of better than 1:10 million. Most of the update sheets (G.01 to G.09) and IBCM were compiled primarily at scales of the order of 1:1 million. Revised sheet 5.12 was compiled at 1:5 million and issued in 1994.)*



3.0 DATA SETS INCLUDED IN THIS RELEASE

3.1 GEBCO Contours and Trackline Control

As mentioned, the source material for the First Release of the GDA was obtained by digitising the bathymetric contours, coastlines and tracklines from the 18 sheets of the printed version of the Fifth Edition of GEBCO as published by the Canadian Hydrographic Service. The series comprises 16 sheets on Mercator projection at a scale of 1:10 million (at the equator) in the region 72°S to 72°N and two polar sheets on polar stereographic projection at a scale of 1:6 million at 75° latitude. The geographic coverage of the individual sheets used in the preparation of the First Release is shown in fig 1.

It should be noted that, whereas most of the Fifth Edition sheets were published between 1978 and 1982, a revised version of Sheet 5.12 (see Annex L.12) was published in 1994 and a pre-publication copy of this sheet was digitised for inclusion in the First Release of the GDA using material compiled at a scale of 1:5 million. The preparation of Sheet 5.12 represented the first example of the use of digital techniques for updating the GEBCO. This approach is now continued with the release of the Centenary Edition of the GDA.

In addition to the bathymetry of the GEBCO Fifth Edition, the First Release of the GDA also included the digitised contours and coastline of the 1:1 million scale First Edition of the International Bathymetric Chart of the Mediterranean (IBCM) (see Annex J). Unfortunately, the trackline control information from the IBCM was not digitised. Furthermore, as the Mediterranean is essentially a closed sea in the cartographic sense, the IBCM data set was not merged with the GEBCO contours but rather left as a stand alone data set. This separation continues in the Centenary Edition.

In recent years, GEBCO has been able to benefit from outputs provided by a number of IOC Regional Ocean Mapping Projects in addition to the IBCM including the International Bathymetric Chart of the Caribbean Sea and Gulf of Mexico (IBCCA), the International Bathymetric Chart of the Central Eastern Atlantic (IBCEA) and the International Bathymetric Chart of the Arctic Ocean (IBCAO). Unlike the IBCM, the 1:1 million scale outputs made available from these projects have been ‘stitched’ into the GEBCO bathymetry.

The geographic coverage of the revised bathymetric contour data sets included in the Centenary Edition of the GEBCO Digital Atlas is shown in fig.2 where the updated areas are numbered in the sequence G.01 to G.09. These comprise the following compilations:

G.01: Arctic Ocean (see Annex K.1)
The contours for this region were compiled in 2001 from the gridded data set of the IBCAO and were prepared for GEBCO by Norman Cherkis (formerly of the Naval Research Laboratory, Washington) and Martin Jakobsson (University of New Hampshire, Durham).

G.02: North-east Atlantic off the British Isles (see Annex K.2)
Compiled in February 1997 and originally published as sheet 97.3 in the 1997 release of the GEBCO Digital Atlas. This sheet was assembled by Peter M. Hunter, Southampton Oceanography Centre, U.K. from bathymetric charts compiled at the Institute of Oceanographic Sciences, Wormley, Surrey, U.K.

G.03: Caribbean Sea and the Gulf of Mexico (see Annex K.3)
Two sets of updated bathymetry were submitted to GEBCO for this region:

a) IBCCA Sheets 1.01 to 1.04 prepared by the National Geophysical Data Center, Boulder for the Northern Gulf of Mexico and the Atlantic Ocean east of Florida;

b) IBCCA Sheets 1.05 to 1.09 for the Southern Gulf of Mexico and the northern part of the Caribbean from José Frias Salazar at the Instituto Nacional de Estadística, Geografía e Informática (INEGI) in Mexico.

G.04: North-east Atlantic off the Iberian Peninsula (see Annex K.4)
This sheet is a composite of three bathymetric compilations:

a) Bathymetric Chart of the Bay of Biscay, published in 1994, and compiled by IFREMER Centre de Brest, France;
b) IBCEA Sheet 1.01 published in February 2002 by the Instituto Hidrografico, Lisbon, Portugal;
c) a bathymetric compilation of the area between Madeira and the Strait of Gibraltar compiled for GEBCO in 2000 by Peter M. Hunter, Southampton Oceanography Centre, U.K.

G.05: Mid Atlantic Ridge to North-west Africa (see Annex K.5)
Compiled for GEBCO in 2002 by Peter M. Hunter, Southampton Oceanography Centre, U.K. and including IBCEA Sheet 1.06 published by the Service hydrographique et océanographique de la marine (SHOM) in Brest, France.

G.06: Central Eastern Atlantic (see Annex K.6)
Updated bathymetry for this area comprises IBCEA Sheets 1.08 to 1.12 published by the Service hydrographique et océanographique de la marine (SHOM) in Brest, France and delivered to GEBCO in digital form.

G.07: Weddell Sea and the Bransfield Strait (see Annex K.7)
An updated bathymetric chart for the Weddell Sea was provided to GEBCO by Hans-Werner Schenke and his co-workers at the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany. It also includes contributions from Gleb B. Udintsev and his colleagues at the Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow.

G.08: Greater Indian Ocean (see Annex K.8)
This is by far the largest contribution to the updating of GEBCO, covering almost a quarter of the world's oceans and extending out to 12°W in the Atlantic and to 170°E in the Pacific. It was compiled by Dr Robert L Fisher at the Scripps Institution of Oceanography, La Jolla, and represents a major personal achievement of considerable benefit to GEBCO and its user community. The contours were compiled on some 250 sheets at a scale of four inches per degree longitude (approximately 1:1 million) over a ten year period up to 2002. The hand drawn contour sheets, with accompanying trackline sheets, were digitised by Pauline Weatherall at BODC. In addition to the original 500 sheets (contours and tracklines), over 600 sections of update charts were delivered to BODC for digitising during the project. The work was completed in September 2002.

G.09: Waters around New Zealand (see Annex K.9)
The regional bathymetric map of New Zealand was delivered as a contribution to GEBCO by Ian Wright of the National Institute of Water and Atmospheric Research (NIWA) in Wellington. The data were submitted to BODC in digital form in 2000.

BODC completed its work on incorporating these data into the GEBCO Digital Atlas in October 2002. In merging the new sheets into the GDA, careful attention was paid to edgematching the basic GEBCO contours (i.e. 200m, 500m and 500m intervals thereafter) across the boundaries of the sheets into the surrounding GDA bathymetry so as to maintain seamless bathymetry. Adjustments were made as necessary, taking due account of the underlying trackline control information - the adjustments were normally made from outside

the boundaries of the new sheets i.e. within the existing GDA bathymetry. Intermediate contours were only edgematched if present on both sides of the boundary.

Incorporating the new sheets into the GDA involved the assimilation not only of the contours and associated coastlines, but also of the trackline control information identifying the echo-sounding data available for compiling the contours. Trackline control information is stored in one of three forms (each identified in the data with a different feature code): as trackline vectors; as locations of individual soundings; or as documented survey boxes. In the latter case, the outlines of the survey boxes are digitised and linked with an explanatory note, available to the user through the GDA Software Interface by setting the cursor in query mode within the area of the survey box. Survey boxes often indicate areas of high-quality surveys or saturated sounding coverage, but they may also represent areas where pre-compiled bathymetric contours were taken from other sources.

It will be noted that much of the new material was compiled at scales of the order of 1:1 million i.e. at a considerably enhanced scale compared with the 1:10 million scale of the GEBCO Fifth Edition. This reflects the move of GEBCO away from the fixed scale paper chart and the ultimate goal of enhancing GEBCO with the best available bathymetry. It should be stressed that the assignment of a scale to a bathymetric sheet simply reflects the scale of the compilation sheet used in its preparation. It does not imply that all seafloor features within the area of the sheet are mapped to that scale. The resolution (or even presence) of features is dependent on the density of sounding coverage and this is usually highly variable - indeed there are often large gaps between tracks.

The Centenary Edition of the GDA includes all bathymetric contours assimilated into the GDA up to October 2002, together with the associated coastlines and trackline control. This data set appears in two forms; one tailored for user-selected display/export through the GDA Software Interface, while the other is available as a set of standalone ASCII files directly accessible by the user. The contours and coastlines of the IBCM are also available in both forms.

3.2 GEBCO's Gridded Bathymetric Data Sets

GEBCO make available two bathymetric grids.

- The **GEBCO_2014 Grid** — a global 30 arc-second interval grid
    - Released: December 2014 — largely generated by combining quality-controlled ship depth soundings with interpolation between sounding points guided by satellite-derived gravity data. Where they improve on this existing grid, data sets developed by other methods are included. The grid is an updated version of the GEBCO_08 Grid.
    - The GEBCO_2014 Grid is accompanied by a Source Identifer (SID) Grid. This data set identifies which grid cells in the GEBCO_2014 Grid are based on bathymetric soundings or bathymetric depth values from grids and which cells contain predicted depth values. Further information about the format of the data set is given in Annex N.
    - The **GEBCO One Minute Grid** — a global one arc-minute interval grid.
    - Released: 2003, updated: 2008 — largely based on the most recent set of bathymetric contours contained within the GEBCO Digital Atlas.

Please note that GEBCO's gridded data sets can be downloaded from the web: http://www.bodc.ac.uk/data/online_delivery/gebco/.

3.2.1 The GEBCO One Minute Grid

The GEBCO One Minute Grid is a global terrain model for ocean and land at one arc-minute intervals. It includes land elevations from the IGBP GLOBE database. It is based on the October 2002 version of the GDA contours (as contained in the Centenary Edition) but with supplementary data for a number of shallow water areas and semi-enclosed seas. Additional control contours and sounding data were used in some areas to constrain the gridding process.

Version 2.0 of the grid was released in November 2008. It is included in the GDA CDROM set. This release contains version 2.23 of the IBCAO grid and updates in shallow water coastal regions for areas around Pakistan and India, the Korean Peninsula and around South Africa. Further details can be found in Annex M of this document.

It must be stressed that, although the GEBCO grid is presented at one-minute intervals of latitude and longitude so as to replicate the GEBCO contours, this does not imply that knowledge is available on seafloor depth at this resolution - indeed the depth in most one minute squares of the world's oceans has yet to be measured.

The GEBCO One Minute Grid is presented in the Centenary Edition of the GDA on disc 1 as one global netCDF data file. In this form, it is therefore directly available to UNIX users. Alternatively, users may prefer to visualise/export user-selected areas of the grid through the GDA Software Interface.

Users are referred to the 'User Guide to the GEBCO One Minute Grid' for a full account of the development of the grid, the methods used to generate the grid, the quality and limitations of the grid and the format and compatibility of the grid. The User Guide was prepared by the GEBCO gridding team and includes an Appendix detailing the problems of generating a grid from the GEBCO contours.

3.2.2. GEBCO_2014 Grid

The GEBCO_2014 Grid is a global terrain model for ocean and land at 30 arc-second intervals. It was released in December 2014. The grid was generated by combining quality-controlled ship depth soundings with interpolation between sounding points guided by satellite-derived gravity data. However, in areas where they improve on the existing GEBCO_2014 grid, data sets generated by other methods have been included. The land data are largely taken from the Shuttle Radar Topography Mission (SRTM30) data set.

The grid is an updated version of the GEBCO_08 Grid. See Annex N for further information on the development of the grid and the data sets included in it.

3.2.3. GEBCO_2014 Source Identifier (SID) Grid

The GEBCO_2014 Grid is accompanied by a Source Identifier (SID) Grid. This data set identifies which grid cells in the GEBCO_2014 Grid are based on bathymetric soundings or bathymetric depth values from grids and which cells contain predicted depth values.

Further information about the data sets can be found in Annex N.

3.3 Coastlines

Once the GEBCO Digital Atlas had been initialized by digitising the published sheets of the GEBCO Fifth Edition, the updating of GEBCO bathymetry was no longer constrained by scale. However, by its very nature, the GEBCO Fifth Edition coastline, based primarily on the Carte Générale du Monde of the Institut Geographique National, Paris, was suited only for use at scales of the order of 1:10 million.

In 1989, a search was instigated for an alternative coastline satisfying the criteria that it should be a) digital, b) suitable for use at scales up to 1:250,000, c) global in coverage and d) of consistent accuracy across the globe. It was fortunate that, just at that time, the US Defense Mapping Agency (DMA) released its World Vector Shoreline (WVS) (see Annex D) - the only coastline able to satisfy the GEBCO criteria. Following a review of the WVS, the GEBCO Guiding Committee agreed that it should be adopted as the standard coastline for future use in GEBCO, and the DMA generously gave GEBCO permission to use WVS in the GEBCO Digital Atlas. The WVS has also been adopted as the standard coastline for use in IOC's Regional Ocean Mapping Projects.

In non-polar regions of the world, the coastline is simply the boundary between the land and the sea. However, in the Antarctic, the concept of a coastline is more complex and needs to represent the boundary between three domains viz. land, sea and ice shelf. Furthermore, the WVS is known to be suspect around Antarctica. With the publication of the SCAR Antarctic Digital Database in 1993 (see Annex E), a high quality seamless and coherent coastline of Antarctica became available for the first time. Not only is it in digital vector form but it also clearly codifies the different types of coastline and includes a far more comprehensive definition of ice shelf limits than has been available hitherto. Compiled from a combination of existing maps and satellite imagery, this new coastline is suitable for use at scales of up to 1:1 million.

With the kind agreement of SCAR, it was decided to standardise the GEBCO coastline south of 60°S on the SCAR Coastline and to replace the WVS in this area with the SCAR Coastline. As there are no coasts crossing the 60°S latitude, which is the boundary between the two data sets, there are no discontinuities of coastline.

For those areas where the bathymetry has not been updated since the GEBCO Fifth Edition, the digital coastline included with the GDA bathymetry remains as portrayed on the GEBCO Fifth Edition sheets i.e. based at a scale of 1:10 million on the Carte Générale du Monde, or for the Antarctic continent, on earlier maps provided by the Scott Polar Research Institute in Cambridge, England. However, as the bathymetry of each area is updated, the coastline within the area is being replaced with the WVS and/or the SCAR coastline as appropriate. During the updating, checks are made to ensure that the bathymetry and coastline are consistent e.g. the bathymetry does not cross the coastline. It will be noted that the coastlines used with the update sheets G.01 to G.09 (and also revised sheet 5.12) have been taken from the WVS and/or SCAR data sets.

Although the WVS and SCAR coastlines are only merged in with the GEBCO bathymetry as and when the bathymetry is updated, complete copies of these coastline data sets are available on the Centenary Edition of the GDA. User-selected extracts may be displayed/exported through the GDA Software Interface. In the case of the SCAR coastline, a stand alone ASCII version is also available for direct access by the user. The WVS is available at scales of 1:250,000; 1:1 million; 1:3 million; 1:12 million and 1:43 million while the SCAR coastline is at scales of full resolution; 1:1 million; 1:5 million and 1:10 million.

3.4 Geographic Names

Included in Centenary Edition are geographically referenced lists of the names of undersea features, ports and cities, oceanic islands, Antarctic islands and Antarctic stations. This information (see Annex G) is available to the user via queryable feature symbols that can be overlain on the map area of charts displayed on the user's screen through the GDA Software Interface. Separate symbols are used for undersea features, islands and place names on land.

The IHO/IOC Gazetteer of Geographical Names of Undersea Features, which is maintained at the International Hydrographic Bureau (IHB) in Monaco on a computerised database system, forms the authoritative source of undersea feature names. It is kept regularly updated with new geographical names as and when they are approved by the GEBCO Sub-Committee on Undersea Feature Names (SCUFN). A copy of the IHB database was used as the source material for the undersea feature names in the GDA and it includes all names approved by SCUFN up to September 2002. Information extracted from the Gazetteer for each undersea feature, and which may be viewed on the user's screen when the feature is queried through the GDA Software Interface, includes:

a) the geographical name of the feature and the generic term used to define the nature of the feature.

b) the geographical position of the feature - this is only an approximate position and is used solely to identify the feature, rather than to define its precise location. Where the feature is extensive, a second position may also be given to indicate its extent. For linear features, such as ridges and fracture zones, further positions may have been added by BODC to delineate the feature.

c) a reference to the GEBCO sheets, IHO Small-Scale International Charts (using the prefix 'INT'), and IOC Regional Ocean Mapping Projects (IBCM, IBCCA, IBCEA and IBCWIO) sheets on which the geographical name and the undersea feature are shown or might be added to future editions.

d) where available, information on the naming of the feature such as the proposer of the name and the date of the proposal; the discoverer of the feature and the date of discovery; reference to the GEBCO SCUFN/SCGN meeting at which the name was approved and the nature of the supporting evidence; and a brief history of the origin of the name.

Please note that, on occasion, named features will appear when there is no obvious indication of the feature in the GDA bathymetry. In general this implies that the echo-sounding data used to identify the feature was not available when the GEBCO contours in the area were compiled.

Users wishing to obtain a full copy of the IHO/IOC Gazetteer of Geographical Names of Undersea Features are directed to the GEBCO website at www.ngdc.noaa.gov/mgg/gebco where it is available in the form of a spreadsheet.

It should be stressed that the use of geographic names in the GDA must not be construed as having any legal or political connotation whatsoever. They are intended purely for geographic convenience and, in the case of undersea features, for encouraging the standardisation of names on nautical and bathymetric charts.

3.5 Inventory of data held at the IHO Data Centre for Digital Bathymetry

At an international level, the global data base of echo-sounding data is maintained in digital form at the IHO Data Centre for Digital Bathymetry (DCDB), which was established in June 1990. The Data Centre (see Annex F) is operated on behalf of the IHO by the US National Geophysical Data Center (NGDC) in Boulder, Colorado.

The IHO DCDB's digital holdings of single beam echo-sounding data are co-held within NGDC's GEODAS database of worldwide underway geophysics data - a major international database of underway bathymetry, magnetics, gravity and seismic shot-point data.

From time to time, the GEODAS database is published by NGDC on CDROM, complete with supporting access software. As further data are acquired at NGDC they are made available to users over the Internet before then being included in the next release of the GEODAS CDROM. Incorporated within the search and retrieval facility of the package is a trackline inventory comprising a simplified navigation file for each cruise leg contributing data to the database. Sufficient navigation points are included in the inventory to replicate the trackline coverage of echo-sounding data lodged in the database. For use within the GEBCO Digital Atlas, Dan Metzger of NGDC kindly provided BODC with a copy of this trackline inventory, updated to cover the data available as of 1 June 2002.

The trackline inventory of echo-sounding data has been reformatted at BODC into unlabelled trackline vectors in geographic coordinates in a similar manner to the trackline control information associated with the GEBCO bathymetry. This information is included in the Centenary Edition of the GDA both in a form for user selected display/export through the GDA Software Interface and as stand alone ASCII files for direct access by the user.

3.6 Echo-sounding correction tables

Measurements of seafloor depths using echo-sounding techniques depend on knowledge of the mean velocity of sound in the water column between the echo-sounding device and the seafloor. This in turn is dependent on the temperature and salinity down the water column and these characteristics vary across the world's oceans. Most modern echo-sounders assume a sound speed of 1500 m/s while some earlier versions assume 800 fm/s (1463 m/s). Since 1929, when the First Edition of Matthews Tables was published, standard correction tables have been used to correct for the true speed of sound in seawater - for this purpose the world's oceans are divided into discrete areas linking regions with common sound velocity profiles, and a table is constructed for each area with the depth correction to be applied at various depths down the water column.

In 1980, a Third Edition of the Echo-Sounding Correction Tables (see Annex H) was published by the U.K. Hydrographic Department to replace Matthews Tables and these were adopted in 1982 by the XIIth International Hydrographic Conference at Monaco.

The Centenary Edition of the GDA contains a directly accessible set of files and software routines (Directory CARTER on disc 1) to enable the user to set up his own system for computing the echo-sounding correction, according to the Third Edition Tables, given the ship position and the uncorrected depth reading. In addition, the GDA Software Interface also provides a facility for automatically computing the echo-sounding correction at the geographic position of the cursor on the user's display screen.

4.0 MAIN FEATURES OF THE GDA SOFTWARE INTERFACE

The GDA Software Interface provides the user with wide-ranging facilities for displaying, querying and exporting data from the various data sets contained in the Centenary Edition of the GEBCO Digital Atlas. Many of the data sets can be overlain with each other for simultaneous display.

The software has been developed to run on an IBM-compatible PC operating under Microsoft *Windows 95* or later. It is controlled by a system of dropdown menus and toolbar buttons and requires a minimum of computing expertise on the part of the user. The low learning overhead afforded by the system ensures that the novice user is able to operate the Atlas system to good effect almost immediately, without the need for special training or for extensive reading of reference manuals.

An online 'help' system is provided with the software in the form of a 'hot-linked' version of the User Guide to the GDA Software, which is directly accessible to the user through the 'help' menu. Useful help is provided to enable the new user to get started.

Version 2.12 of the GDA Software Interface was released in May 2009 and is included in this CDROM set.

A brief overview of the main features of the GDA Software Interface is given below (details concerning the export of data are given in section 5):

* A choice of map projections is available to display the data: Equidistant Cylindrical, Mercator, Miller Cylindrical, Lambert Cylindrical Equal Area and Polar Stereographic.

* Initial geographic area selection is made by chart number, by chart area, by geographic latitude and longitude limits or by a user-controlled zoom box. This initially selected area becomes the 'basemap'.

* Within the initially selected 'basemap' area, the user can zoom in and out of their particular area of interest and pan across to adjacent areas as required. Any export of data from the GDA will be based on the data in the area of the displayed map.

* A coloured backdrop to the map can be generated from GEBCO's gridded data sets with colour coding according to depth and elevation as selected by the user.

* 'Cross-section' depth/elevation profiles can be displayed for user-specified sections across the map. The profiles can be filled with colour coded according to depth and elevation.

* Bathymetric contours can be displayed on the map from either the GEBCO chart series or, in the case of the Mediterranean, the IBCM First Edition.

* Facilities are provided for selecting the depths of contours to be displayed on the map and for assigning colours to them.

* A cursor-controlled querying facility is available for displaying the value of any displayed contour.

* The user is offered a choice of coastlines for display on the map; either the coastline used in the chart series (GEBCO or IBCM) or the World Vector Shoreline (SCAR coastline of Antarctica south of 60°S)

* When accessing the GEBCO series, the map can be overlaid with trackline control information (ship's tracks, isolated sounding points and survey boxes) indicating the data used in the compilation of the GEBCO contours. A cursor-initiated query within any survey box present in the viewing area will result in the details of the survey being displayed on the screen.

* Alternatively, the display can be overlaid with tracklines indicating the echo sounding data available from the IHO Data Centre for Digital Bathymetry as of June 2002. It should be noted that not all of these data were necessarily available when the GEBCO contours were compiled.

* A magnify option allows you to display the area under the cursor as if it were viewed through a magnifying lens. The image is displayed in a 'magnified view' window shown in the display area. As you move the cursor across the screen the image in the 'magnified view' window changes.

* Display the position of features from the International Hydrographic Organization (IHO)/ Intergovernmental Oceanographic Commission (IOC) Gazetteer of Geographic Names of Undersea Features by feature type.

* Display feature names for single point and two point features from the IHO/IOC Gazetteer of Geographic Names of Undersea Features in the map display area.

* Select to display your own file(s) of point data in the map display area. Up to ten files can be displayed at one time.

* The display area can also be overlaid with symbols showing the locations of undersea features, oceanic islands, ports/cities and Antarctic islands and stations. A cursor controlled querying facility is available for displaying the names (and supporting documentation in the case of undersea features) of these features on the screen.

* A geographic graticule can be overlaid for reference on the display area.

* The geographic coordinates, depth (or elevation) and echo-sounding correction can be displayed at the current cursor position.

* A multi-point distance measuring option is available between user specified points on the map display with distance presented in miles, nautical miles and kilometres.

* Supporting documentation for the source charts contributing to the displayed map can be displayed or listed out on demand.

5.0 EXPORTING DATA

5.1 Accessing GEBCO's gridded data sets

GEBCO's gridded data sets are stored in the directory Grid on disc 1 as global GMT-compatible netCDF data files, which may be accessed either directly by the user or through the GDA Software Interface. Using the GDA Software Interface, the entire gridded data sets or geographic subsets of the grids may be exported into the user's own files either in a simple ASCII format or in the netCDF format. Details concerning the formatting of gridded data may be found in Table 1.

5.2 Exporting vector data using the GDA Software Interface

All the vector data sets contained in the Centenary Edition can be exported into the user's own files through the GDA Software Interface. Through this interface the user can define precisely their geographic area of interest, irrespective of sheet boundaries. The user can also specify which contour levels are to be selected and trackline vectors (tracklines, survey box outlines and sounding points) can be merged in the same file as the bathymetric contours and coastlines. Furthermore, a choice of coastlines and coastline scales is offered and, if required, the user can export data from the IBCM as an alternative or from the GEODAS trackline inventory. The choice of data to be included in the output is at the user's discretion.

When vector streams are exported through the GDA Software Interface, the user is offered a choice of formats. The vectors can either be exported in the simple flat ASCII format described in Table 2 or in DXF or Shapefile formats as described in Table 4.

When exporting coastlines in areas including the Antarctic coast, the user can choose either to include the full range of Antarctic coastline feature codes or to use a simplified version just labelling the landward limit of seawater and the seaward limit of floating permanent ice.

5.3 Directly accessible vector data in ASCII format

Exporting vector data through the GDA Software Interface has the advantage that the user can specify a geographic area of interest irrespective of sheet boundaries and can select which features are to be included in the export file. However, for those users not able to make use of this software, the Centenary Edition also contains a directly accessible set of simple flat ASCII files. These include:

** 20 files encompassing the full set of GEBCO bathymetric contours and their associated coastlines. Each file covers an area of 60° latitude by 60° longitude except that two areas are further sub-divided by latitude.
(Stored in the CONTOURS Directory on disc 2)

** 20 files of the GEBCO trackline control information (including tracklines, survey box outlines and sounding points) complementing the above files of bathymetric contours.
(Stored in the TRACKS Directory on disc 2)

** 10 files of the IBCM First Edition bathymetric contours and coastlines with one IBCM sheet per file.
(Stored in IBCM Directory on disc 2)

** 1 file of GEODAS bathymetric tracklines showing the coverage of echo-sounding data held at the IHO Data Centre for Digital Bathymetry as of June 2002.
(Stored in the GEODAS Directory on disc 2)

** 4 files of SCAR Antarctic Coastlines with one file for each of the scales, 1:10 million; 1:5 million; 1:1 million and the original scale of the source material. Each file contains a full coastline with features coded in the range '22010' to '22100' as defined in Table 3.
(Stored in the SCAR Directory on disc 2)

Each of the above directly accessible files is built up as a series of vector streams relating to bathymetric contours, coastlines or trackline control information. Each file is formatted in the same flat ASCII format as described in Table 2. Each Directory has a 'readme' file describing its contents.

The Centenary Edition does not contain a directly accessible ASCII version of the World Vector Shoreline (WVS). Users wishing to obtain their own copy of the WVS, or parts thereof, in ASCII format are advised to export it through the GDA Software Interface.

The Centenary Edition also includes a set of ASCII text files (stored in the Directory ASCIIDOC on disc 1) containing the supporting documentation for each of the vector data sets of the GDA, including a documentation file for each of the GEBCO sheets. This supporting documentation is also accessible through the GDA Software Interface and is also included in the various Annexes of the present User Guide.

Table 1: Formats for GEBCO Gridded Data

The available GEBCO gridded data sets are stored as global netCDF data files, which may be accessed either directly by the user or through the GDA Software Interface.

Information concerning netCDF can be found at the
URL: http://www.unidata.ucar.edu/packages/netcdf/

The netCDF files are compatible with the GMT (Generic Mapping Tools)
system: (http://gmt.soest.hawaii.edu/)

Within the netCDF format, the grids are stored as a one-dimensional array of 2-byte signed integer values.

For the GEBCO One Minute Grid the complete data set gives global coverage. It consists of 10,801 x 21,601 data values, one for each minute of latitude and longitude, resulting in a total of 233,312,401 points. The data start at position 90°N, 180°W and are arranged in latitudinal bands of 360 degrees x 60 points/degree + 1 = 21,601 values. The data range eastward from 180°W to 180°E i.e. the 180° value is repeated. Thus, the first band contains 21,601 repeated values for 90°N, then followed by a band of 21,601 values at 89°59'N and so on at one minute latitude intervals down to 90°S. The data values are grid line registered i.e. they refer to the elevation at the grid points.

For the GEBCO_2014 Grid and Source Identifier (SID) Grid the complete data sets give global coverage and each file consists of 21,600 rows x 43,200 columns, resulting in 933,120,000 data points. The data start at the Northwest corner of the files, i.e. for the global files, position 89° 59' 45''N, 179° 59' 45''W and are arranged in latitudinal bands of 360 degrees x 120 points/degree = 43,200 values. The data range eastward from 179° 59' 45''W to 179° 59' 45''E. Thus, the first band contains 43,200 values for 89° 59' 45''N, followed by a band of 43,200 values at 89°59' 15''N and so on at 30 arc-second latitude intervals down to 89° 59' 45''S. The data values are pixel centre registered i.e. they refer to values at the centre of grid cells.

Grid cell coding: For the GEBCO One Minute Grid and GEBCO_2014 Grid the grid cell values represent elevation in metres, with negative values for bathymetric depth and positive values for topographic heights. Please see the documentation which accompanies the GEBCO_2014 Grid for further information about the coding of the SID file.

<u>Export through the GDA Software Interface</u>

The entire GEBCO grids or geographic subsets of the data sets can be exported in netCDF or simple ASCII formats, including an ASCII format suitable for conversion to an ESRI raster file. Please see the GEBCO Digital Atlas Software Interface Users' Guide for more details.

TABLE 2. Simple ASCII Format for GDA Vector Data

Note: this format has been modified slightly since the 1994 and 1997 releases of the GDA, with the inclusion of a flag character 'IFLAG' to mark a header record.

Within this format, files are built up as a series of labelled vector streams relating to bathymetric contours, coastlines, tracklines, survey box outlines or sounding points. A new vector stream is started for each contour segment, coastline segment, trackline, survey box outline or sounding point.

Each vector stream consists of coordinate pair records preceded by a header record containing a flag character set to '>', a feature code 'ICODE' (as in Table 3) for the vector, and a count 'ICOUNT' of the number of succeeding coordinate pairs making up the vector.

Each co-ordinate pair is stored in a record with a geographic latitude 'ALAT' and longitude 'ALONG', each expressed in decimal degrees.

Each record is made up of 20 bytes as follows:

Header record: IFLAG, ICODE, ICOUNT in format (A1,2I6,5X),CR,LF
Co-ordinate pair record: ALAT, ALONG in format (F8.4,F10.4),CR,LF

In the CD-ROM ASCII files, latitude is stored in the range -90° to +90° with north positive and south negative; and longitude is stored in the range -180° to +180° with east positive and west negative. When data are exported to this format from the GDA Software Interface, it is also possible for the user to specify that longitude should be stored in the range 0° to 360°.

Ordering/contiguity of vectors

CD-ROM ASCII files: Within each file, the vector streams are stored in ascending order of their feature code value 'ICODE'. In general, the GEBCO coastline and the basic GEBCO contours (200m, 500m and at 500m intervals thereafter) are continuous (i.e. without gaps) and should be contiguous within the geographic area of each ASCII file. For closed contours, the first point of the vector should have the same coordinates as the last point. Likewise, the IBCM data should be contiguous within their sheet boundaries. SCAR coastlines are only contiguous along the length of each feature within the sheet limits of the original source material - contiguity breaks down when the feature code changes.

Through the GDA Software Interface: Within the GDA, the vector data are split into ten degree squares and, on export, the vectors are ordered first by ten degree square and then by feature code. If required, the user can request output ordered only by feature code but should be aware that the ordering process creates temporary disc files on the user's PC. Exporting ordered data for a large area may therefore require a large amount of free disc space. In splitting the vectors into ten degree squares, points were generated at the boundary of the squares for vectors crossing the ten degree boundaries. If required, the user can request that the vector segments are joined up on export providing they are first ordered as described above.

TABLE 3. GDA Feature Codes for Vector Data

The following integer based feature coding system is used for labelling GDA vector streams:

'0' for coastlines
'1' for landward limit of seawater (Antarctic coastline)
'2' for seaward limit of floating permanent ice (Antarctic coastline)

'depth in corrected metres' for bathymetric contours

'22010' for ice coastline (definite)
'22011' for rock coastline (definite)
'22012' for grounding line (definite)
'22013' for rock against ice shelf (definite)
'22020' for ice coastline (approximate)
'22021' for rock coastline (approximate)
'22022' for grounding line (approximate)
'22023' for rock against ice shelf (approximate)
'22030' for iceberg tongue
'22040' for floating glacier tongue
'22050' for ice shelf front
‘22090’ for ice rumples (distinct)
‘22100’ for ice rumples (indistinct)

'22222' for tracklines
'22223' for outlines of survey boxes, special compilations or areas of dense sounding coverage
‘22224’ for sounding points

Note: codes ‘1’, ‘2’ and ‘22010 to ‘22100’ correspond to Antarctic related coastlines. ASCII files stored on the CD-ROM do not use codes ‘1’ and ‘2’ - these two codes are only present in files exported through the GDA Software Interface when the user has requested that feature codes ‘22010’ to ‘22023’ and ‘22090’ and ‘22100’ should be combined into feature code ‘1’ and feature codes ‘22030’ to ‘22050’ into feature code ‘2’.

TABLE 4. Proprietary Output Formats for GDA Vector Data

In addition to simple flat ASCII format, the user may also export vector data through the GDA Software Interface in the two commonly used GIS formats, DXF and ESRI Shapefile:

DXF Format

DXF originated as a proprietary format in the commercially available 'AUTOCAD' package, but is now a standard input format for many other commercially available software packages.

In DXF, the vector streams are expressed as polylines in geographic co-ordinates with each contour depth and coastline feature type assigned to a separate layer and a separate logical colour. Likewise, separate layers and logical colours are also assigned for tracklines, survey boxes and sounding points. The latter are expressed as type POINT rather than polylines. Each of the layers is labelled using the feature code definitions listed in Table 3.

ESRI Shapefile

This format is used by ESRI products such as ARCINFO. Further information about the Shapefile format may be found in:

http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf.

Bathymetric contour, coastline and trackline data are exported as line feature types and sounding points as point feature types. Line and point feature types are exported to separate files.

The Shapefile consists of a main file, an index file and a dBASE table. When the user enters a file name through the GDA Software Interface, three files will be created. For example, if the data are to be saved with the name area1.shp, files ‘area1.shx’ (index file) and ‘area1.dbf’ (dBASE file) will also be created. A further set of three files (‘area1Soundings.dbf’, ‘area1Soundings.shp’ and ‘area1Soundings.shx’) will be created should the exported data include point features i.e. positions of sounding points. If the exported data consists of only point features then the chosen name is used.

ANNEX A
Historical Background to GEBCO

First Edition

GEBCO was initiated at the turn of the century by HSH Prince Albert I of Monaco. It traces its origins to discussions held during the Seventh International Geographic Congress in Berlin in 1899 which resulted in a Commission being set up to study the naming of ocean relief features and to draw up plans for a general chart of the oceans. The Commission was composed of ten leading geographers and scientists of the day: HSH Prince Albert I of Monaco, Professor O. Krummel, Admiral S.O. Makarow, Dr. H.R. Mill, Sir John Murray, Dr. Fridtjof Nansen, Professor O. Petersson, Baron Richtofen, Professor A. Supan and Professor J. Thoulet.

The Commission met in Wiesbaden in April 1903 under the chairmanship of Prince Albert and gratefully accepted the Prince's offer to organise and finance the production of a new series to be designated "The General Bathymetric Chart of the Oceans (GEBCO)". The series, on a scale of 1:10 million, was to be composed of 16 sheets on Mercator projection, together with 8 sheets on gnomonic projection covering the polar regions.

Work on the First Edition of GEBCO began in June 1903 with a team of seven draughtsmen under the direction of Lieutenant Ch. Sauerwein. Extremely rapid progress was made and the series was completed in a period of 7 months. The lithographed charts were presented to the Paris Academy of Sciences in January 1904, and later in the year to the Eighth International Geographical Congress in Washington, D.C. In making the presentation, Professor Thoulet remarked ".....Here then is everything that is known about the relief of the ocean floor. For many years to come, mariners, telegraphists, engineers, oceanographers and scientists will continue their soundings, for now we must proceed to fill in the details; no point of any sea on the globe will escape our investigations....."

The First Edition contained over 18,000 soundings selected mainly from British Admiralty Charts with additional data incorporated from soundings obtained by cable-laying vessels. Depth contours were shown at 200m, 500m, 1000m and at 1000m intervals thereafter.

Second Edition

At the opening of the Oceanographic Museum at Monaco in 1910, Prince Albert called together an international committee of experts to discuss the production of a Second Edition of GEBCO. The first sheets of the Second Edition were published in 1912 but the last did not appear until 1930. World War I broke out when only a part of the series had been printed and Prince Albert died in 1922. Dr. Jules Richard, Director of the Oceanographic Museum, supervised the production of the remaining sheets of the series according to the wishes expressed in the Prince's will.

For the Second Edition the number of soundings had increased to 30,000. Dr. Richard, writing in 1930 remarked "The second edition (1912-1930) is much more complete than the first.....The assembled coloured sheets form a magnificent chart of unique type. It is particularly interesting as an ensemble; it shows up in a striking fashion the gaps in our knowledge of the relief of the sea bottom. It shows us clearly what has yet to be done to fill these gaps.....the present chart must be retained; it must be completed little by little and thus brought to perfection.....The gaps are enormous, some of them are several hundreds of thousands of square kilometres in extent. In these days echo-sounding will make it easier to fill them up than in the past, for a vessel can take soundings while underway....."

Almost up to World War II, all soundings in the deep ocean were discrete wire soundings, obtained laboriously by a very small number of ships that could spare the time to stop on station for lengthy periods for the sole purpose of obtaining one spot ocean depth. As a result, the few deep ocean soundings obtained each year could be published in the form of lists, by certain national Hydrographic Offices; the major sources of data were the "Lists of Oceanic Depths" published regularly by the British Admiralty since 1888, the French "Annales Hydrographiques" and the German "Annalen der Hydrographie". However, with the advent of the echo-sounder, this approach soon became impractical.

Third Edition

There was a major change in organisation for the production of the Third Edition of GEBCO. Following the death of Prince Albert, his scientific team was disbanded and the Government of Monaco invited the International Hydrographic Bureau (now the International Hydrographic Organization) to take over the project. In 1929, the Bureau was entrusted with the task of keeping the series up-to-date and of collating all data outside the continental shelf.

Data for the Third Edition were compiled by the IHB staff, and hydrographic offices of the IHO Member States were requested to supply all available oceanic soundings. These took the form of lists of depths together with the 'exact' geographical position and details of sounding apparatus, sea temperatures, velocity of sound in seawater etc. To collate the soundings, the IHB established a series of 1001 plotting sheets on Mercator projection at a scale of 1:1 million projection. From these plotting sheets the contour lines were compiled and soundings for inclusion on the GEBCO 1:10 million series were selected.

Publication began in 1932 but work on the Third Edition progressed slowly and was never completed; the effect of World War II and the rising flood of new data were contributing factors but the main reason was the lack of financial support which restricted deployment of resources to a single draughtsman.

Fourth Edition

The VIth International Hydrographic Conference, 1952, saw the need for a Fourth Edition of GEBCO and, with the amount of bathymetric data continuing to increase rapidly, decided that the sheets should be updated on a 5-year cycle. Consequently, the Fourth Edition was started in 1958 before the Third Edition had been completed. The 2 sheets published in 1958 and 1961 were the last to be based on compilations prepared by the IHB. To produce further sheets from the great wealth of new data becoming available was clearly beyond the resources of the Bureau alone and, accordingly, a new organisational structure was evolved.

The responsibility for maintaining the 1:1 million plotting sheets was taken over by 18 volunteering Hydrographic Offices of IHO Member States, each responsible for a specific area of the world's oceans. The IHB co-ordinated the scheme, ensuring the flow of bathymetric soundings to the appropriate Hydrographic Office.

In 1965, an agreement was reached between the IHB and the French Institut Géographique National (IGN) for the production of the GEBCO Fourth Edition. Responsibility for the cartographic compilation, publication and sales of GEBCO was taken over by IGN, with IHB acting as the co-ordinator for the whole activity. The volunteering Hydrographic Offices supplied IGN with updated copies of their 1:1 million collected soundings sheets for use in compiling the GEBCO sheets. The IGN was responsible for drawing the contours and selecting the soundings, with the French Hydrographic Office verifying this work. The project was overseen by the GEBCO Committee - a consultative body with membership drawn from national Hydrographic Offices, the Scientific Committee on Oceanic Research (SCOR) and

the International Association for the Physical Sciences of the Oceans (IAPSO). An Editorial Board of the Committee was responsible for the verification and correction of geomorphological details.

With the new arrangements, 7 GEBCO sheets, 4 of the Fourth Edition and 3 of the Third Edition, were published between 1966 and 1973. However, under this system there were a number of drawbacks, principally the lack of scientific input in the compilation of the various sheets. These inadequacies were highlighted by the SCOR Working Group on "Morphological Mapping of the Ocean Floor".

Even to the present day, the sounding coverage of the world's oceans is very patchy and often concentrated on isolated tracklines with large gaps in between. When the earlier editions of GEBCO were produced, there was no adequate understanding of the nature and scale of processes which first create and then modify the variety of morphological features of the ocean floor. Only when the theory of Plate Tectonics was developed in the late 1960s did it become possible to understand the processes involved in shaping the ocean floor. The knowledge base developed from the geological and geophysical research of the period enabled scientists, cautiously but with increasing confidence, to infer major linear trends and thus to interpolate between sounding lines in order to produce more meaningful bathymetric charts. This scientific approach to bathymetric mapping was to become one of the key features of the preparation of the Fifth Edition of GEBCO.

ANNEX B
Production of the GEBCO Fifth Edition

In 1972, realising the need for a modernised GEBCO series, the IHO and the IOC decided to co-sponsor an entirely new edition of the GEBCO, to be compiled by marine scientists employing the best available geological and geophysical knowledge of the sea floor.

Production of the series was supervised by a Joint IOC-IHO Guiding Committee for the GEBCO composed of ten members, five nominated by the IHO and five by the IOC. The IHO experts were selected from volunteering Hydrographic Offices in their Member States, whereas the IOC experts, who were nominated after consultation with the Scientific Committee on Oceanic Research (SCOR), the International Association for the Physical Sciences of the Ocean (IAPSO), and the Commission for Marine Geology (CMG), were eminent marine geologists and geophysicists.

The IHO retained responsibility for maintaining the 655 collected soundings sheets on a scale of 1:1 million, and for providing cartographic advice on, and supervision over, the final product. On the other hand, the IOC, in conjunction with SCOR, IAPSO and CMG, was responsible for all scientific input, including contouring of the bathymetric data and compilation of the final waterwork for each sheet.

The collected soundings sheets provided by the volunteering Hydrographic Offices formed a unique data base on which to compile the Fifth Edition. However, by virtue of the fact that these sheets had been compiled over a period of thirty to forty years, the data recorded thereon varied considerably in accuracy, both in depth and position, depending on the sounding apparatus fitted in, and the navigational methods employed by, the numerous ships which had contributed data.

Improved methods of sounding by Precision Depth Recorder using a crystal controlled time base, and navigation using such systems as Omega and the Satellite Navigator, clearly demonstrated the errors to which earlier data were liable. However, in the absence of improved modern data, these data continue to be all that are available in many areas. Although certain areas of the deep sea may be of sufficient commercial, military or scientific importance to be examined closely by saturated surveys, for the greater part of the deep oceans bathymetric charts can only be compiled from random track data of variable quality. The interpretation of such data relies on the expert understanding of marine geologists and geophysicists of the processes shaping the ocean floor.

A major problem facing the preparation of the Fifth Edition was the chronic lack of finance available for GEBCO and the recognition that sales clearly could not begin to cover production costs, at least until the complete world cover was available and the series had been given wide publicity. The breakthrough came when, with remarkable foresight, the Canadian Government agreed to scribe, print and provide sales outlets initially for the first 4 sheets of the series, but later for the full 18 sheets. This agreement was honoured by the Canadian Hydrographic Service, which over the period 1975 to 1982 was responsible for bringing to publication the complete series of 18 Fifth Edition charts. Indeed, at the completion of the project, the CHS also published a World Sheet with global coverage at a scale of 1:35 million.

With this agreement in hand, the Guiding Committee was able to offer marine geoscientists in many countries of the world the possibility of publishing their work, with full acknowledgements, in a prestigious chart series of high quality and thus gain strong support from the leaders of the world marine geoscientific community. However, it could not assist them with project funding and it is a measure of the high regard in which the GEBCO is held that so many eminent marine geoscientists were willing to give their time and energy to the

preparation of one or more sheets of the series, and to obtain institutional or national funding for their in-house work.

For each of the Fifth Edition sheets, one or more Scientific Co-ordinators were appointed who were responsible for co-ordinating and compiling the best possible contour plots for the area of the sheet. They were also responsible for working closely with the Scientific Co-ordinators of adjacent sheets to ensure continuity at borders and on overlaps. An independent review procedure was also set up, through which all sheets had to pass before being cleared for publication.

For the Fifth Edition, the world cover between 72°N and 72°S was, as with earlier editions, on Mercator projection at a scale of 1:10 million at the equator. This required 16 sheets, some of which were given overlap strips so as to ensure that prominent morphological features were shown in their entirety on one sheet and were not cut by an arbitrary geographical border. For the same reason, limits of sheets in the southern hemisphere were shifted by 20° to the east in order to give more satisfactory cover to the main ocean basins.

The polar regions were covered by 2 sheets only (as opposed to 8 in the earlier editions). These were on Polar Stereographic projection at a scale of 1:6 million at 75° latitude, and reached to 64° N and S, thus having a considerable overlap with the Mercator sheets.

A full list of the Scientific Co-ordinators responsible for each sheet is given in Table 1. The land topography and coastlines for the Fifth Edition were taken from the Carte Générale du Monde, by permission of the Institut Géographique National, Paris, France. The Antarctic continent was taken from maps supplied by the Scott Polar Research Institute in Cambridge, England, while the Arctic shoreline was taken from the American Geographical Society Map of the Arctic Region. Each of the sheets depicted contoured bathymetry at standard depths of 200m, 500m and at 500m intervals thereafter, although the actual contours displayed varied slightly as some sheets also included contours at depths intermediate to the standard levels.

To ensure the standardization and general acceptance of the geographical names and the nomenclature used for ocean bottom features in the Fifth Edition, each sheet was carefully scrutinised by the GEBCO Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features. In conformance with the system used by the IHO for its International Nautical Chart series, national versions of geographic names were used for land features (transliterated to the Roman alphabet where appropriate) and English names were used at sea.

An important innovation with the Fifth Edition was the inclusion of sounding control on the face of each sheet. Discrete soundings appear as grey dots and echo-sounding tracks as grey lines in the background to the contours. Saturated areas and areas of high quality surveys are shown in boxes and cross referenced to a note in the border of the sheet. This has enabled far fewer spot depths to be shown (in figures); indeed, these are now virtually confined to maximum and minimum depths of significant features. An even greater advantage is that the chart user can assess the contour reliability as a reliable indication of the amount and spacing of the original data from which the contours were drawn is presented.

It should be noted that a revised version of sheet 5.12 in the South Atlantic was produced in 1994. The GEBCO Guiding Committee decided in 1987 that, as the original version of 5.12 printed in 1978 had been based on rather sparse data and as substantial amounts of new data had become available in the meantime, it would be in order to commission the preparation of a revised version. The compilation and assembly of the contours for the revised sheet was completed in 1993 and it was published by the Canadian Hydrographic Service in 1994.

TABLE 1: Scientific Co-ordinators responsible for compiling the bathymetry on the sheets of the GEBCO Fifth Edition

Sheet No.	Scientific Co-ordinator	Affiliation
5.01	Johannes Ulrich	Institut für Meereskunde an der Universität Kiel, Germany
5.02	Gleb B. Udintsev	Vernadsky Institute of Geochemistry, Moscow, Russia
5.03	G. Leonard Johnson	Office of Naval Research, Arlington, USA
	David Monahan	Canadian Hydrographic Service, Ottawa, Canada
5.04	Anthony S. Laughton	IOS Deacon Laboratory, Wormley, UK
	David Monahan	Canadian Hydrographic Service, Ottawa, Canada
5.05	Anthony S. Laughton	IOS Deacon Laboratory, Wormley, UK
5.06	Yoshio Iwabuchi	Hydrographic Department, MSA, Tokyo, Japan
5.07	Jacqueline Mammerickx & Stuart M. Smith	Scripps Institution of Oceanography, La Jolla, USA
5.08	Roger C. Searle	IOS Deacon Laboratory, Wormley, UK
	David Monahan	Canadian Hydrographic Service, Ottawa, Canada
	G. Leonard Johnson	Office of Naval Research, Arlington, USA
5.09	Robert L. Fisher	Scripps Institution of Oceanography, La Jolla, USA
5.10	David Monahan	Canadian Hydrographic Service, Ottawa, Canada
	Robin K.H. Falconer	Bedford Institute of Oceanography, Dartmouth, Canada & New Zealand Oceanographic Institute, Wellington, New Zealand
	Marie Tharp	Lamont-Doherty Geological Observatory, New York, USA
5.11	Jacqueline Mammerickx & Stuart M. Smith	Scripps Institution of Oceanography, La Jolla, USA
5.12	Peter Hunter	IOS Deacon Laboratory, Wormley, UK
	Norman Cherkis	Naval Research Laboratory, Washington, USA
	Carl Brenner	Lamont-Doherty Geological Observatory, New York, USA
	Gleb B. Udintsev	Vernadsky Institute of Geochemistry, Moscow, Russia
	Robin Falconer & Jane Handley	GeoResearch Associates, Waikanae, New Zealand
5.13	Dennis E. Hayes & Michael Vogel	Lamont-Doherty Geological Observatory, New York, USA
5.14	Robin K.H. Falconer	Bedford Institute of Oceanography, Dartmouth, Canada & New Zealand Oceanographic Institute, Wellington, New Zealand
	Marie Tharp	Lamont-Doherty Geological Observatory, New York, USA
5.15	Jacqueline Mammerickx & Isabel Taylor	Scripps Institution of Oceanography, La Jolla, USA
	Steven Cande	Lamont-Doherty Geological Observatory, New York, USA
5.16	John LaBrecque, Philip D. Rabinowitz & Carl Brenner	Lamont-Doherty Geological Observatory, New York, USA
5.17	G. Leonard Johnson	Office of Naval Research, Arlington, USA
	David Monahan	Canadian Hydrographic Service, Ottawa, Canada
	Gisle Grønlie	University of Oslo, Norway
	Lawrence W. Sobczak	Department of Energy, Mines and Resources, Ottawa, Canada
5.18	G. Leonard Johnson	Office of Naval Research, Arlington, USA
	Jean-René Vanney	Université Pierre et Marie Curie, Paris, France

ANNEX C
Digitization of the GEBCO Fifth Edition

Digitization of the Fifth Edition proved a major task and took the best part of ten years to complete (1984-1993). As usual, funding was a major problem and the provision of resources for the work was dependent on the foresight and goodwill of national agencies. The successful completion of the task was dependent on the generous cooperation of two organisations in particular; the French Institut Géographique National through support given to the Bureau Gravimétrique International in Toulouse; and the UK's Natural Environment Research Council (NERC) through support given to the British Oceanographic Data Centre (BODC).

The digitization of the bathymetric contours and coastlines of the Fifth Edition was carried out, on a sheet by sheet basis, at four laboratories:

* Bureau Gravimétrique International, Toulouse, France - 11 sheets
* NERC Unit for Thematic Information Systems, Reading, UK - 4 sheets
* Head Department of Navigation and Oceanography, St. Petersburg, Russia - 1 sheet
* British Oceanographic Data Centre, Bidston, UK - 2 sheets

Quality control, final editing and reformatting of these data into a uniform data set was carried out by the British Oceanographic Data Centre (BODC).

Stable base transparencies of the master bathymetric contour plates of the published sheets were used as the source material for digitising, except for sheets 5.06 and 5.12. These transparencies were provided by the Canadian Hydrographic Service at the same scale and projection as the published sheets. At each of the participating laboratories the transparencies were raster scanned using laser scanning equipment. The raster output, typically on a 20 dot/mm binary matrix, was converted into unlabelled contour vector streams which were then exhaustively checked and edited using an interactive graphics display terminal. Gaps in contours, caused by contour labels on the published charts, were filled in digitally from the terminal. Each digitised contour stream was then manually assigned an appropriate bathymetric depth by cross reference to the contours on the printed sheets.

All bathymetric contours present on the published sheets were digitised, including the basic GEBCO contours of 200m, 500m, and 500m intervals thereafter. The actual contours depicted vary considerably from sheet to sheet and intermediate contours are often included to better define the bathymetry in certain regions. However, all sheets include, as a minimum, the basic GEBCO contours and these were digitised as closed contours without open ends. All contour levels are expressed in corrected metres i.e. based on echo-soundings corrected for the speed of sound according to the Echo-Sounding Correction Tables.

On occasions where it was difficult to identify contour values without ambiguity, reference was made back to the Scientific Co-ordinator(s) for the sheet, the IHO collected soundings sheets or the digital sounding data held at the National Geophysical Data Center, Boulder, USA.

Prior to their final release, the digitised contours for each sheet were reviewed in detail at BODC. This review involved plotting out the contour vectors, on the same scale and projection as the published sheet, and checking out in detail the registration and labelling of each vector - no mean feat considering that the 18 Fifth Edition sheets produced some

95,000 contour segments. BODC's checks on the digitised sheets confirmed that the techniques adopted at the participating laboratories were able to reproduce the Fifth Edition contours to an accuracy comparable with the line thickness of the contours on the published sheets.

As already mentioned, the digitization was carried out on a sheet by sheet basis. Where the published sheets overlap in geographic coverage, only one version of the overlapping area was digitised i.e. that shown on the most recently compiled sheet. Edge matching was carried out across the sheets to ensure the digitised data provide a seamless bathymetry across the globe. Thus, digitised contours at sheet boundaries may not always accord with those on the printed sheets, although any adjustments made were carried out taking due account of the underlying trackline control information.

The two polar sheets (5.17 and 5.18) were only digitised to the 72° latitude i.e. they were not digitised where they overlapped adjacent Mercator sheets.

For sheet 5.06 in the Western Pacific, the digital contours and coastline for the area from 100°E to 180°E were taken directly from a digital data base maintained by the Japan Oceanographic Data Center, Tokyo. An earlier version of this data base had in fact formed the basis for the published sheet.

Rather than digitize the outdated version of 5.12, BODC collaborated in the production of the revised version of this sheet. The revised contouring of various sections of the sheet was carried out by scientists in the USA, Russia, New Zealand and the UK and, following review by two nominated GEBCO experts, their hand drawn contours were sent to BODC for digitising and for compiling into a single seamless sheet. The contents of the digitised file were later used as the base from which a revised sheet was published by the Canadian Hydrographic Service in 1994.

The coastline was digitised from the Fifth Edition sheets. It was based on the Carte Générale du Monde of the Institut Géographique National in Paris, France, and, for the Antarctic continent, on maps provided by the Scott Polar Research Institute in Cambridge, England. However, there are two exceptions:

a) for the region 50°S to 7°N; 70°W to 20°E of revised GEBCO sheet 5.12, the digital coastline was taken from the high resolution World Vector Shoreline digital data set reduced in volume by 84% using the Douglas-Peucker algorithm with a lateral tolerance of 0.04mm at a scale of 1:5,737,447.

b) for the region 0°N to 46°40'N; 100°E to 180°E, the coastline was provided in digital form by the Japan Oceanographic Data Center based on their standard 1:1 million bathymetric charts of the region. The volume of this data set was reduced by 89% using the Douglas-Peucker algorithm with a lateral tolerance of 0.08mm.

Recognising that the digitised contours would be of limited value without corresponding information on the distribution of soundings used in their original compilation, it was decided that the trackline control should also be digitised from the Fifth Edition sheets. Using almost identical techniques and procedures to those used in digitising the bathymetric contours and coastlines, the tracklines from the Fifth Edition were digitised on a sheet by sheet basis by three organisations in Russia, Germany and the UK thus:

* British Oceanographic Data Centre, Bidston, UK - 13 sheets
* Head Department of Navigation and Oceanography, St. Petersburg, Russia - 3 sheets
* Alfred-Wegener-Institut, Bremerhaven, Germany - 2 sheets

Quality control, final editing and reformatting of these data into a uniform data set was again performed at BODC, with the work being carried out over a 3 year period between 1990 and 1993. The Canadian Hydrographic Service kindly collaborated again by providing stable base transparencies of the master, trackline control plates of the published Fifth Edition sheets for use in digitising. As before, raster scanning techniques using laser scanning equipment provided the basis for the digitization, with the final output being in the form of trackline vectors.

The outlines of survey boxes (together with their supporting text) were digitised as well as the individual ship tracklines. In areas where sheets overlapped, the tracklines were only digitised on the sheet from which the bathymetric contours had been digitised. For the area of sheet 5.06 between 100°E and 180°E, the tracklines were digitised from transparencies taken from the trackline plates used to produce the 1:1 million scale atlas published by the Japan Oceanographic Data Center, which complemented the digital data set of bathymetric contours and coastlines already supplied to BODC for that area. Likewise, for the area of sheet 5.12, the tracklines were digitised from source material provided by the compilers of the revised bathymetry for the new version of the sheet.

The complete data set of the digital contours, coastlines and tracklines for the GEBCO Fifth Edition was finalised in June 1993 thereby providing a high quality digital base from which future editions of GEBCO might evolve.

ANNEX D
World Vector Shoreline (WVS)

WVS was produced by the US National Imagery and Mapping Agency (formerly the US Defense Mapping Agency) and has been adopted as the standard world coastline for the updating of GEBCO north of 60°S.

(Note: south of 60°S, the WVS has been replaced for GEBCO use by the SCAR (Scientific Committee on Antarctic Research) coastline of Antarctica)

Once the GEBCO Digital Atlas had been initialized by digitising the published sheets of the GEBCO Fifth Edition, the updating of GEBCO bathymetry was no longer constrained by scale. It was anticipated that it could well be updated in certain regions at scales of up to 1:500,000 (or even 1:250,000 in isolated cases). However, by its very nature, the GEBCO Fifth Edition coastline, based primarily on the Carte du Monde of the Institut Geographique National, Paris, was suited only for use at scales of the order of 1:10 million.

In 1989, a search was instigated by the GEBCO Sub-Committee on Digital Bathymetry for an alternative coastline satisfying the criteria that it should be a) digital, b) suitable for use at scales up to 1:250,000, c) global in coverage and d) of consistent accuracy across the globe. It was fortunate that, just at that time, the US Defense Mapping Agency (DMA) released its World Vector Shoreline (WVS) - the only coastline able to satisfy the GEBCO criteria. Acting on the advice of its Subcommittee, the GEBCO Guiding Committee agreed that WVS should be adopted as the standard coastline for future use in GEBCO, and the DMA generously gave GEBCO permission to use WVS in the GEBCO Digital Atlas. The WVS has also been adopted as the standard coastline for use in IOC's Regional Ocean Mapping Projects.

A description of the WVS may be found in Soluri,E.A. and V.A.Woodson (1990), ‘World Vector Shoreline’, International Hydrographic Review, Vol.LXVII(1), p27-36.

The WVS was developed by the DMA as a digital data file, at a nominal scale of 1:250,000 and referenced to the World Geodetic System (WGS-84) datum. Worldwide coverage of the data set was completed in July 1989, working to a specification that 90% of all identifiable shoreline features should be located within 500 metres (i.e. 2mm at 1:250,000) of their true geographic position with respect to the WGS-84 datum.

The main source material for the WVS was DMA's Digital Landmass Blanking (DLMB) database which was derived primarily from the Joint Operations Graphics and coastal nautical charts produced by DMA. The DLMB data consisted of a land/water flag file on a 3 by 3 arc-second interval geographic grid. This raster database was converted into vector form to create WVS and explains the 3 arc-second stepping interval apparent in the coastline when plotted out at high scale. For areas of the world not covered by the DLMB database, the shoreline was taken from the best available hard copy sources at a preferred scale of 1:250,000 (or up to 1:125,000 where the source data allowed).

The WVS is a truly impressive product but some uncertainty remains in that the accuracy specification (500m -see above) for 90% of WVS gives no indication of the accuracy for the remaining 10% of the world or where the areas of lesser accuracy occur. It was anticipated that the main area of reduced accuracy occurred around Antarctica and, with the publication of a high quality (1:1 million scale) coastline of Antarctica by SCAR in 1993, it was decided to remove the WVS coastline south of 60°S and to replace it with the SCAR coastline.

As yet, the WVS has not been matched to the digitised bathymetric contours of the GEBCO Fifth Edition and isolated occurrences may arise where WVS appears in conflict with the bathymetry e.g. around oceanic islands and where the shoreline abuts a submarine scarp. Such mismatch is mainly a consequence of the different scale and resolution of the two data sets. The WVS is being phased in with the GEBCO bathymetry as and when the bathymetry is updated with new data. This has already occurred for the revised bathymetry of GEBCO sheet 5.12, and the update sheets G.01 to G.09, where WVS was used as the source of the coastline north of 60°S.

In addition to its 'full resolution' version, simplified versions of WVS also exist at scales corresponding to 1 to 43 million; 1 to 12 million; 1 to 3 million; 1 to 1 million; and 1 to 250,000. The lower resolution data sets are simplified versions of the basic product obtained by filtering out points using the Douglas-Peucker algorithm so as to produce a lower data volume. In its original form, the WVS was organized in one degree square units and shoreline continuity was ensured by including the coordinates of all shoreline crossovers with whole degree latitude and longitude lines. These points appear to have been retained at each step during the simplification process with the result that, for the 1:43 million scale shoreline, they appear to have a disproportionate influence on the simplified shoreline. However, this effect is only noticeable if the shoreline is viewed at scales greater than 1:43 million and serves to illustrate that the simplified shorelines should only be used at scales less than or equal to their nominal scales.

South of 60°S, the SCAR coastline is also available at a range of scales and these have been matched to WVS as follows:

WVS (1:43 million) with SCAR (1:10 million)
WVS (1:12 million) with SCAR (1:10 million)
WVS (1:3 million) with SCAR (1:5 million)
WVS (1:1 million) with SCAR (1:1 million)
WVS (1:250,000) with SCAR (full resolution)

ANNEX E

SCAR Coastline of Antarctica

(Note: The SCAR coastline has been adopted as the standard GEBCO coastline for all areas south of 60°S and will be incorporated with the GEBCO bathymetry as and when the bathymetry is revised.)

Original Source: The Antarctic Digital Database (ADD) CDROM published in 1993 by the ICSU Scientific Committee on Antarctic Research (SCAR) and compiled jointly by the British Antarctic Survey, the Scott Polar Research Institute and the World Conservation Monitoring Centre; Cambridge, UK.

Update Note: Following the CDROM publication of Version 1.0 of the ADD, responsibility for the maintenance and revision of the database was passed to the British Antarctic Survey. Version 2.0 was released in July 1998 available over the World Wide Web and including a number of corrections and minor revisions. Version 3.0 was released in July 2000 on the WWW and is the version currently in use by GEBCO. In Version 3.0, satellite imagery was used to update the position of the fronts of the major ice shelves. It also contains improvements in the area of the Antarctic Peninsula including small rock outcrops and islands omitted in the earlier versions. From a GEBCO perspective, the main revisions compared with Version 1.0 concern the Larsen, Wordie, Wilkins, Ronne and Ross Sea Ice Shelves.

Stop Press: ADD Version 4.0 was released in summer 2002 including a new coastline for the region from 12°E to 168°E provided by the Australian Antarctic Division derived primarily from Landsat images and with a horizontal resolution of 50m. Landsat images have also been used to improve the coastline of the northern part of the Antarctic Peninsula north of 68°S. These revisions have not yet been incorporated into the GEBCO Digital Atlas.

Coverage: Antarctica and surrounding islands out to 60°S

Scale: Coastline compiled at a range of scales from 1:200,000 to 1:1 million depending on availability of detailed maps and imagery.

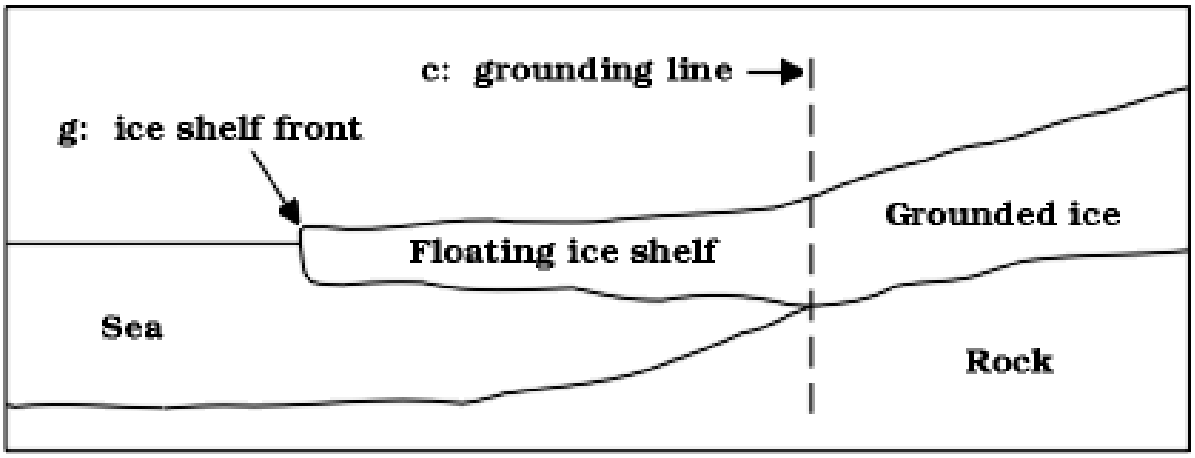
INTRODUCTION

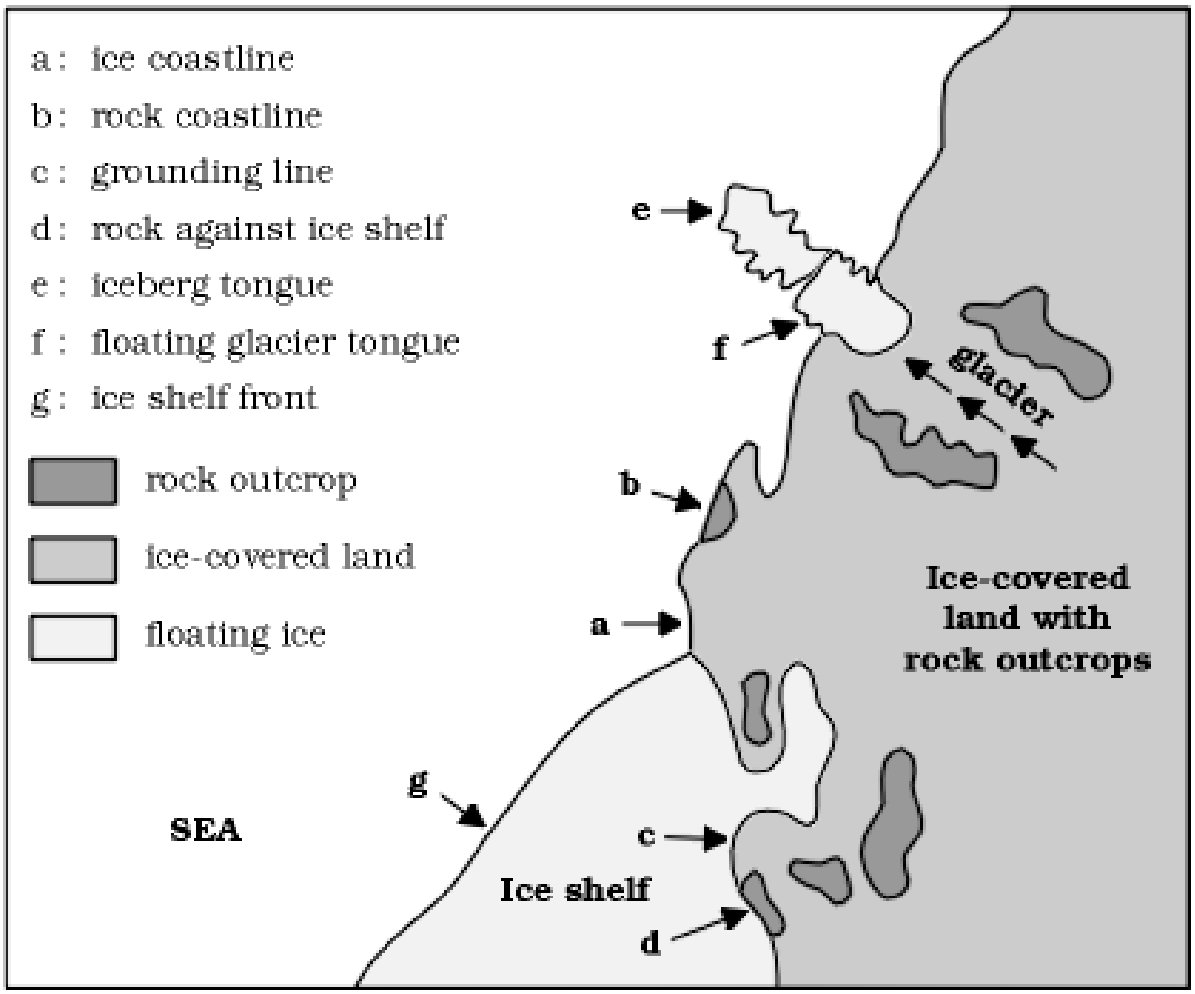
The US National Imagery and Mapping Agency's World Vector Shoreline has been adopted as the standard coastline for use in the updating of GEBCO. Not only is it a high quality product suitable for use at scales of up to 1:250,000 but it has global coverage and is available in digital form. Unfortunately, it is known to be inaccurate around the Antarctic continent but more significantly it does not deal effectively with the presence of ice in the coastal zone.

In non-polar regions of the world, the coastline is simply the boundary between the land and the sea. Being coincident with mean sea level, it also acts as the zero depth contour. However, around Antarctica, the concept of a coastline is more complex and needs to represent the boundary between three domains viz. land, sea and ice shelf.

Along a significant part of the Antarctic coast there is a fringe of permanent floating ice called the ice shelf. Note that the ice shelf does not include the offshore seasonal ice sheet ('sea ice') that breaks up every year.

Schematic Diagram to illustrate the various types of coastline around Antarctica





In the Antarctic, the land surface may manifest itself either as rock or as grounded ice. In the coastal zone, where there are ice shelves, the interface between the two types of permanent ice is represented by a 'grounding line'. This is the line along which the inland ice sheet ceases to be grounded on bedrock and becomes permanent floating ice i.e. ice shelf. It should be noted that the grounding line does not correspond to the zero contour.

There are 8 basic types of coastline represented around Antarctica:

a) ice coastline
b) rock coastline
c) grounding line
d) rock against ice shelf
e) iceberg tongue
f) floating glacier tongue
g) ice shelf front
h) ice rumples

It may be noted that a, b, c, d and h represent the landward limits of seawater - in c and d the seawater lies beneath an ice shelf before reaching its landward limit. On the other hand e, f, g represent the seaward limits of permanent floating ice (as such they are more susceptible to dynamic change).

(Update note: ice rumples were inadvertently omitted in ADD Version 1.0. This is a special case on an ice shelf where the ice is grounded but where the ice is moving with the main mass of the ice shelf rather than having an independent radial flow.)

With the publication of the SCAR Antarctic Digital Database (ADD) in 1993, a high quality seamless and coherent coastline of Antarctica became available for the first time. Not only is it in digital vector form but it also clearly codifies the different types of coastline (as listed above) and includes a far more comprehensive definition of ice shelf limits than has been available hitherto. Compiled from a combination of existing maps and satellite imagery, this new coastline is suitable for use at scales of up to 1:1 million - in mountainous regions it also includes information up to a scale of 1:250,000.

USE OF THE SCAR COASTLINE IN GEBCO

For GEBCO purposes, it has been decided to standardise the coastline south of 60°S on the SCAR Coastline and to replace the World Vector Shoreline in this area with the SCAR Coastline. As there are no coasts crossing the 60°S latitude, which is the boundary between the two data sets, there are no discontinuities of coastline. Furthermore, the SCAR Coastline is available at a range of scales compatible with those available in the World Vector Shoreline.

For use in GEBCO, the British Oceanographic Data Centre initially extracted the SCAR Coastline from the Antarctic Digital Database (ADD) CDROM. However, the updated Version 3.0 coastline was supplied directly to BODC by the British Antarctic Survey. The coastline was converted at BODC into labelled vector streams of paired latitude and longitude values, stored in the same format as used in GEBCO for depth contours. The only difference is that the depth value is replaced by a numeric feature code, in the range 22010 to 22100 that represents the type of coastline as coded in the ADD:

ADD code	GEBCO code	Type of coastline
22010	(1)	Ice coastline (definite)
22011	(1)	Rock coastline (definite)
22012	(1)	Grounding line (definite)
22013	(1)	Rock against ice shelf (definite)
22020	(1)	Ice coastline (approximate)
22021	(1)	Rock coastline (approximate)
22022	(1)	Grounding line (approximate)
22023	(1)	Rock against ice shelf (approximate)
22030	(2)	Iceberg tongue
22040	(2)	Floating glacier tongue
22050	(2)	Ice shelf front
22090	(1)	Ice rumples (distinct)
22100	(1)	Ice rumples (indistinct)

The coding of some features is subdivided into 'definite' and 'approximate' so as to flag those features whose definition is uncertain either through the lack of good quality imagery or detailed maps - more specifically it reflects the inherent difficulty of interpreting the grounding line from satellite images.

Although the full ADD code is maintained in the GEBCO Digital Atlas, a simplified GEBCO version is also available, coded as follows:

1 = Landward limit of seawater

2 = Seaward limit of floating permanent ice

The SCAR Coastline is available at four different scales:

** Full resolution - contains data at their original scale of capture from the source material. For most of the coastline, the data were captured from maps at scales of 1:200,000 (only two map sheets), 1:250,000, 1:500,000 and 1:1 million. Interpretations from satellite images were used where no suitable maps of the coastline existed.

** At reduced scales of 1:1 million; 1:5 million and 1:10 million respectively. Reductions were achieved by a process of simplification, smoothing and removal of points. In these reduced versions, features coded as 'approximate' are recoded to their 'definite' equivalents. The only codes present in the reduced versions are 22010, 22011, 22012, 22013, 22040, 22050 and 22090. (Note: due to a coding error in the preparation of the 1:1 million coastline, floating glacier tongues, 22040, were inadvertently coded as ice shelf front, 22050)

All four versions have been extracted from the ADD for use in GEBCO and have been merged with their nearest equivalent scaled versions of the World Vector Shoreline.

PREPARATION OF THE SCAR COASTLINE (VERSION 1.0)

The base material for constructing the Antarctic coastline was prepared by digitising printed topographic maps produced by national mapping agencies and Antarctic research institutes. For most of the coastline these maps were available at scales ranging from 1:200,000 to 1:1

million. In general the maps had been published without recourse to satellite imagery. When merging the data from the different map series to create a seamless coastline, reference was made to satellite images as these usually provided a clearer overview of the shape and position of coastal features.

The quality of the coastline was greatly enhanced through the interpretive analysis of Landsat images by Dr. Charles Swithinbank at the Scott Polar Research Institute. Reasonable Landsat coverage was available for most of the coastline in the form of 1:1 million scale photographic products. The digitised map sheets were plotted out at 1:1 million scale on clear acetate film which was then overlaid on the satellite images. Enhanced detail of the coastline and linework interpretations of features such as grounding lines and ice fronts indicated on the satellite images were transferred by hand to the film overlays using headlands and rock outcrops for position control. The revised vector data were digitised directly from the acetate sheets and then compared with the original map-derived versions. In complicated areas where more detailed maps (1:250,000 scale) were available, the revised data were modified to accord with the detail shown on the original maps.

Much of the coastline of Dronning Maud Land between 5°E and 45°E was not covered by conventional, medium-scale linework maps. The coastline for this sector was prepared at Cambridge by digitising interpreted vector data direct from photographic products of Landsat multi-spectral scanner scenes, at 1:500,000 scale. Features identified on each scene and on the corresponding published maps of the area (where available) provided control for the photo-mosaic.

The digital coastline vectors covering the Filchner-Ronne Ice Shelf and parts of Ellsworth Land, Coats Land and western Neuschwabenland, between 80°W and 5°E, were prepared by the Institut fur Angewandte Geodasie, Frankfurt am Main and the Alfred-Wegener-Institut fur Polar und Meeresforschung, Bremerhaven. These were derived from a geocoded raster mosaic of Landsat multi-spectral scanner images with a scale of data capture of 1:400,000.

Reference was made to other sources as appropriate. For example, due to recent changes to the ice front of the Ross Ice Shelf, reference was made to:

Keys, H.J.R., Jacobs, S.S. & Barnett, D. (1990) The calving and drift of iceberg B-9 in the Ross Sea, Antarctica. Antarctic Science, 2(3), p.243-257

THE ANTARCTIC DIGITAL DATABASE (ADD)

Although the GEBCO interest in the ADD is primarily as the source of a high quality Antarctic coastline, it should be noted that the ADD is a comprehensive (within the limits of present knowledge) GIS orientated topographic/cartographic database of the Antarctic continent.

The ADD was created by a Cambridge, UK, consortium consisting of the British Antarctic Survey, the Scott Polar Research Institute and the World Conservation Monitoring Centre. They are the authors of the database. Under the auspices of SCAR, eight nations (Argentina, Australia, China, Germany, New Zealand, Norway, Poland and UK) contributed data to the project and three others (Japan, Russia and USA) gave permission for their published maps to be digitised. The greater part of the project was funded by the British Petroleum Co.

The ADD was published by SCAR in 1993 in the form of a single CDROM, accompanied by an extensive 156 page 'User's guide and reference manual' edited by Mrs. Janet W. Thomson of the British Antarctic Survey. This volume also includes a detailed bibliography of all the source material used in the compilation of the ADD. The CDROM has been designed

for PC use within the ESRI (Environmental Systems Research Institute Inc.) ArcView software. The data may also be viewed and manipulated through ESRI's PC ARC/INFO which can be used to transfer the data into other systems.

Thematic layers present in the ADD include: coastlines; ice and rock cliffs; contours or formline elevations; geodetic height data; locations of bird or seal colonies; glacier flowlines; glacier margins; isolated ice hillocks or domes; outlines of lakes and meltpools; outlines of moraines; place names from national gazetteers; outlines of exposed rock areas; meltwater streams; tracks of overland traverses; historic sites and monuments; special protected areas; sites of special scientific interest and a layer relating to sites of human activity.

The ADD is maintained by the Mapping and Geographic Information Centre (MAGIC) of the British Antarctic Survey.

Although Version 1.0 of the ADD was published on CDROM, subsequent versions have been made available on the World Wide Web:

Web address: http://www.add.scar.org/

ANNEX F

IHO Data Centre for Digital Bathymetry (DCDB)

The first international system for compiling sounding data on a worldwide basis was established in 1903 by HSH Prince Albert I of Monaco. Following his death in 1922, the Government of Monaco invited the International Hydrographic Bureau (now the International Hydrographic Organization) to take over the scheme. In 1929, the Bureau was entrusted with this task by the International Hydrographic Conference, and a world series of Ocean Plotting Sheets was established, at a scale of 1:1 million on Mercator projection, on which to record and publish all sounding data outside the continental shelf. Up until World War II, the data was comparatively sparse and could be handled by the small staff at the disposal of the Bureau.

By the mid-1950s, a great wealth of modern data became available and it was clearly beyond the resources of the Bureau alone to maintain the soundings data bank. Consequently, in order to ensure that the 1:1 million plotting sheets could be kept up to date, a network was established involving the services of volunteering Hydrographic Offices in 18 IHO Member States. Each of the Volunteering Hydrographic Offices (VHOs) accepted responsibility for compiling bathymetric data in specific geographic areas and for periodically updating the 1:1 million collected soundings sheets in their area of responsibility.

Individual Hydrographic Offices were charged with ensuring the regular supply of bathymetric data to the appropriate VHO, and the IHB in Monaco maintained a co-ordinating role in this scheme, issuing information on the status of the various sheets from time to time. Copies of the soundings sheets were available to the user community on direct application to the appropriate VHO - a nominal charge was usually made to cover the cost of copying. When the ICSU World Data Centre (WDC) system was established following the International Geophysical Year in the late 1950s, the IHO became recognised as the World Data Centre for Bathymetry.

The Ocean Plotting Sheets formed the base from which much of the contouring of the GEBCO 5th Edition was compiled. However, during the preparation of the 5th Edition in the early 1980s, it became apparent that a number of the GEBCO scientists responsible for undertaking the contouring had at their disposal considerably more data than appeared on the 1:1 million sheets maintained by the VHOs. The shortfall in data submission to the VHOs appeared closely related to the introduction of computer techniques for the handling of bathymetric data, particularly in the geoscience community. Since the late 1960s, geoscientists had been finding it far more convenient to store and exchange their data in computer files and to plot out data automatically as and when the need arose. Computer techniques also enabled far greater volumes (and densities) of echo-sounding data to be handled than could be readily hand scribed onto plotting sheets.

The GEBCO Sub-Committee on Digital Bathymetry (SCDB) reviewed this situation in 1986, recognising that a major part of the missing data might well be found in the underway marine geophysics database maintained by the US National Geophysical Data Center (NGDC) in Boulder. At that time, the Boulder centre held almost 2,000 cruises of bathymetric, magnetic and gravity data, primarily from US laboratories but also with contributions from Japan, France, Russia, UK, New Zealand, Canada, South Africa and China. The database already included over seven million nautical miles of digital echo-sounding data and had clearly demonstrated the practicality and value of computing techniques for managing such data.

The SCDB advised that, in pursuing its goal of maintaining a global collection of sounding data for the deep ocean, the IHO should seek to collaborate with the US NGDC in creating a

digital database for sounding data. At its meeting in Paris in 1986, the SCDB drafted supporting documentation to facilitate such collaboration. In 1987, the US Government submitted a proposal based on the SCDB documentation to the XIIIth International Hydrographic Conference for the establishment of an IHO Data Centre for Digital Bathymetry (DCDB) to be operated by the US NGDC on behalf of the IHO. In 1990, the IHO Member States agreed to this proposal and on 1st June 1990 the IHO DCDB was duly established, co-located with the US NGDC in Boulder.

The IHO database of digital, single beam echo-sounding data is co-held within NGDC's GEODAS (Geophysical Data System) database of worldwide underway geophysics data.

The data set is available from: www.ngdc.noaa.gov/mgg/geodas

ANNEX G

Geographic Names in the GEBCO Digital Atlas

BACKGROUND

Since its inception at the turn of the century, GEBCO has been intimately concerned with the nomenclature and terminology used for the naming of undersea features. It plays an international role in the naming of undersea features falling entirely or mainly (more than 50%) outside territorial waters.

In 1974, the GEBCO Guiding Committee established a Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features (renamed in 1993, the GEBCO Sub-Committee on Undersea Feature Names) with the main objective of advising on names and nomenclature to be used on the GEBCO charts. The Sub-Committee developed a list of definitions for undersea feature terms, which were subsequently discussed with the Working Group on Maritime and Undersea Features of the United Nations Group of Experts on Geographical Names. As a result of these discussions a set of joint guidelines, together with principles and procedures for naming features, a name proposal form, and a list of terms and definitions, was worked out in accordance with the provisions of appropriate resolutions of United Nations Conferences on Geographical Names. The resulting document entitled "Standardization of Undersea Feature Names" was published by the IHB as IHO-IOC Publication BP-0006 (now B-6) and may be found on the GEBCO website.

The Sub-Committee played a key role in ensuring the standardization of the geographical names and nomenclature used for ocean bottom features on the sheets of the GEBCO Fifth Edition. During the Ninth Session of the GEBCO Guiding Committee in 1983, the IHB was requested to prepare a Gazetteer of the geographical names of undersea features shown on the GEBCO Fifth Edition and on the IHO Small-Scale INTernational Chart Series (1:2.25 million and smaller), so that they could be used on other chart series and assist in the standardization of feature names. The IHB accepted the task, particularly since the small-scale INT charts, produced by IHO Member States, were increasingly showing more detailed ocean morphology with more geographical names.

The first edition of the Gazetteer was published by the IHB in November 1988 as IHO-IOC Publication BP-0008 (now B-8). It included the geographical names shown on the GEBCO Fifth Edition and on the small-scale INT charts published up to February 1988, as well as the new geographical names approved by the GEBCO Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features at its meeting in April 1987. The Gazetteer is kept updated by the IHB using a computer based system and new names are added as and when they are approved by the Sub-Committee.

In 1987, the parent bodies of GEBCO i.e. the IHO and the IOC, both adopted similar motions aimed at improving the standardization of naming undersea features in an effort to curb the indiscriminate and unregulated naming of undersea features in articles submitted to professional journals, or on ocean charts or maps. New names were appearing without any close scrutiny being made concerning their suitability, or even whether the feature had already been discovered and named. The motions strongly encouraged marine scientists and other persons in Member States wishing to name undersea features to:

"check their proposals with published Gazetteers of Undersea Feature Names, taking into account the guidelines contained in the IHO/IOC publication 'Standardization of Undersea Feature Names' (including the use of the 'Undersea Feature Name Proposal Form contained therein), to submit all proposed new names for clearance, either to their national authority or,

where no such national authority exists, to the IOC or IHB, for consideration by the 'GEBCO Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features', which may advise on any potential confusing duplication of names." It is now generally understood that proposals for the naming of undersea features located in international waters should be sent directly to the IHB or the IOC

The motions also called on Member States "to invite publishers of ocean maps, and editors of scientific journals, in their country, to require compilers and authors to provide written evidence of such clearance before accepting for publication any maps or scientific articles containing new names for undersea features."

GEOGRAPHIC NAMES IN THE GEBCO DIGITAL ATLAS

The GEBCO Digital Atlas includes geographically referenced lists of the names of undersea features, oceanic islands, Antarctic islands, Antarctic stations, ports and cities. This information is available to the user via queryable feature symbols that can be overlain on the map area of charts displayed on the user's screen through the GDA Software Interface. In the case of undersea features, extended information is displayed covering relevant details on the naming of the feature as stored in the IHO/IOC Gazetteer. Separate symbols are used for undersea features, islands and place names on land.

It should be stressed that the use of geographic names in the GDA must not be construed as having any legal or political connotation whatsoever. They are intended purely for geographic convenience and, in the case of undersea features, for encouraging the standardisation of names on nautical and bathymetric charts.

Undersea Features

The IHO/IOC Gazetteer of Geographical Names of Undersea Features is maintained at the IHB in Monaco on a computerised database system. It is kept regularly updated with new geographical names as and when they are approved by the GEBCO Sub-Committee on Undersea Feature Names (SCUFN).

A copy of the IHB database was used as the source material for the undersea feature names in the GDA and it includes all names approved by the GEBCO SCUFN up to September 2002. Information extracted from the Gazetteer for each undersea feature, and which may be viewed on the user's screen when the feature is queried through the GDA Software Interface, includes:

a) the geographical name of the feature and the generic term used to define the nature of the feature.

b) the geographical position of the feature - this is only an approximate position and is used solely to identify the feature, rather than to define its precise location. Where the feature is extensive, a second position may also be given to indicate its extent. For linear features, such as ridges and fracture zones, further positions may have been added by BODC to delineate the feature.

c) a reference to the GEBCO sheets, IHO Small-Scale International Charts (using the prefix 'INT'), and IOC Regional Ocean Mapping Projects (IBCM, IBCCA, IBCEA and IBCWIO) sheets on which the geographical name and the undersea feature are shown or might be added to future editions.

d) where available, information on the naming of the feature such as the proposer of the name and the date of the proposal; the discoverer of the feature and the date of discovery; reference to the GEBCO SCUFN/SCGN meeting at which the name was approved and the nature of the supporting evidence; and a brief history of the origin of the name. Information may also be given on any variations or changes in the name, or any differences with the name adopted for the feature by the 'Advisory Committee on Undersea Features of the U.S. Board on Geographic Names (ACUF/BGN)'.

Please note that, on occasion, named features will appear when there is no obvious indication of the feature in the GDA bathymetry. In general this implies that the echo-sounding data used to identify the feature was not available when the GEBCO contours in the area were compiled.

Users wishing to obtain a full copy of the IHO/IOC Gazetteer of Geographical Names of Undersea Features are directed to the GEBCO website at www.ngdc.noaa.gov/mgg/gebco where it is available in the form of a spreadsheet.

Oceanic and Antarctic Islands

A geographically referenced list of about 400 oceanic islands was specially prepared by BODC to complement the GDA. The list is not intended to be comprehensive in any way nor are the names given to the individual islands intended to be definitive. The list focuses primarily on small islands in the open ocean and excludes islands in the Mediterranean, the Gulf of Mexico, the Caribbean Sea (except for the Windward and Leeward Islands) and the inner seas of South East Asia. It also excludes islands on the continental shelves in close proximity to land and all continental shelf islands in the Arctic Circle.

An initial list of islands was prepared using the names printed on the sheets of the GEBCO Fifth Edition, but this was then extended by reference to the Times Atlas of the World (Comprehensive Edition), particularly in the areas of Micronesia, Melanesia and Polynesia in the Pacific Ocean. In general, an attempt was made to identify all isolated islands but, in island groups, only a few key islands were identified. The name of the island group is included in parenthesis after the island name where appropriate.

Island names were taken either from the GEBCO Fifth Edition sheets or from the Times Atlas of the World and follow the naming and language conventions adopted by these two sources. Inevitably, the list contains a mixture of anglicised and local language names. The geographic coordinates of each island were determined by reference to the World Vector Shoreline. Using the GDA Software Interface, each island was zoomed into in turn on a PC screen and the screen cursor was set within its confines - the geographic coordinates of the cursor were then read off the automatic cursor coordinates display.

The GDA also includes a geographically referenced list of the Antarctic islands named on the GEBCO Fifth Edition sheets. The island names were taken directly from these sheets and the geographic coordinates of islands close to the ice shelf were determined by reference to the digitised coastline of the GEBCO Fifth Edition, using the GDA Software Interface in a similar manner to that outlined above for oceanic islands.

Ports/Cities and Antarctic Stations

The GDA includes a geographically referenced list of all ports and cities annotated on the sheets of the GEBCO Fifth Edition. Their names are taken directly from these sheets and their geographical coordinates were taken from the Gazetteer in the Times Atlas of the World (Comprehensive Edition). These coordinates were checked relative to the digitised version of the GEBCO Fifth Edition coastline viewed through the GDA Software Interface.

The GDA also includes a geographically referenced list of scientific stations operating in Antarctica south of 60°S during the Antarctic winter of 1991. The list covers stations occupied by the member nations of the ICSU Scientific Committee on Antarctic Research and was reproduced from SCAR Bulletin, No 103 (October 1991).

ANNEX H
Echo-Sounding Correction Tables

Measurements of seafloor depths using echo-sounding techniques depend on knowledge of the mean velocity of sound in the water column between the echo-sounding device and the seafloor. This in turn is dependent on the temperature and salinity down the water column and these characteristics vary across the world's oceans. Most modern echo-sounders assume a sound speed of 1500 m/s while some earlier versions assume 800 fm/s (1463 m/s). Since 1929, when the First Edition of Matthews Tables was published, standard correction tables have been used to correct for the true speed of sound in seawater - for this purpose the world's oceans are divided into discrete areas linking regions with common sound velocity profiles, and a table is constructed for each area with the depth correction to be applied at various depths down the water column.

In 1939, a Second Edition of Matthews Tables was published and these tables remained in common use until the early 1980s (Matthews, D.J., 1939. Tables of the velocity of sound in pure water and sea water for use in echo-sounding and sound ranging (Second edition). British Admiralty Hydrographic Department, Publication H.D. 282, London, 52p).

In 1980, a Third Edition of the Echo-Sounding Correction Tables was published by the U.K. Hydrographic Department to replace Matthews Tables. The tables were extensively revised to incorporate the large number of temperature and salinity measurements obtained since 1939 and used an improved formula for the dependence of sound velocity on temperature and salinity. Computations for the revised tables were carried out by D.J.T. Carter of the Institute of Oceanographic Sciences, Wormley, England, using oceanographic station data provided by the U.S. National Oceanographic Data Center, Washington. The revised tables, together with a detailed description of their preparation may be found in 'Echo-Sounding Correction Tables (Third Edition) in Publication N.P.139 of the U.K. Hydrographic Department. In 1982, the XIIth International Hydrographic Conference at Monaco adopted the Third Edition Tables to replace Matthews Tables (Second Edition).

The Third Edition Tables are applicable for use throughout the world in water depths greater than 200 metres, and cover depth to the sea bed in each of 85 echo-sounding areas. The tables are in metres and cater for echo-sounders calibrated to 1500 m/s, a conversion table for 1463 m/s being provided. As the boundaries between echo-sounding correction areas lie along exact degrees of latitude and longitude, the tables are particularly suited for computerised use.

The Centenary Edition of the GDA (Directory CARTER on disc 1) contains a directly accessible set of files to enable the user to set up his own system for computing the echo-sounding correction, according to the Third Edition Tables, given the ship position and the uncorrected depth reading. The files include the echo-sounding correction area definitions and correction tables, together with the necessary computer routines and documentation for installing the system.

In addition, the GDA Software Interface also provides a facility for automatically computing the echo-sounding correction at the geographic position of the cursor on the user's display screen - the user simply supplies the uncorrected depth reading and the system returns the echo-sounding correction area identifier and the corrected depth value or vice versa.

ANNEX I

Procedures for updating GEBCO Contours

The GEBCO Digital Atlas (GDA) forms the base from which future printed editions of GEBCO will be generated. However, rather than being geared towards the printing schedules of such future editions, the updating of the GEBCO through the GDA will be a continual process. Without the scale constraints of the printed chart, it is envisaged that improved bathymetric compilations will be merged into GEBCO at scales ranging from 1:10 million up to 1:500,000 (or larger scales in isolated cases). This will be achieved by 'stitching in' so as to maintain the seamless nature of the data set. Use of larger scale material for any given area will be dependent on there being an adequate density of sounding data therein to justify its inclusion.

In order to maintain the high quality and global nature of GEBCO, it is necessary to set standards on the new material used for its updating. Prior to their inclusion in the GDA, new updated bathymetric compilations in any given area need to conform to the following principles:

a) contours should be expressed in corrected metres.

b) as a minimum, the GEBCO basic contours of 200m, 500m, 1000m and at 500m intervals thereafter should be included. Where appropriate, the inclusion of contours at 20m, 50m and 100m is to be encouraged. Where additional intermediate contours are included an interval of 100m is recommended.

c) the GEBCO basic contours should be continuous within the compilation area.

d) contours cutting the edges of the compilation area should be 'stitched in' to those in the surrounding area of the GDA - in general the 'stitching in' should be from outside the compilation area rather than from inside.

e) in coastal zones and around islands, the contours should be compatible with the World Vector Shoreline (or the SCAR coastline of Antarctica).

f) compilations submitted should be accompanied by the ship tracks and survey boxes (annotated with their source) used in compiling the contours.

g) the updating material should normally consist of digital contours - if submitted in hard copy form, sufficient graticule points should be included within and at the edges of the map to enable potential distortions to be checked through subsequent digitising and if necessary corrected.

h) compilation methods should be fully described in supporting documentation, including details of the projection, ellipsoid and scale used, as well as information on any additional support material that might have been used e.g. magnetic surveys, sonar images, satellite altimetry, proprietary compilations; the names and affiliation of the authors of the map; the data sources used; and the date the map was compiled.

i) in international waters, the names of newly named undersea features should be submitted for approval to the GEBCO Sub-Committee on Undersea Feature Names, or to the appropriate national authority where they fall within territorial waters.

j) updated compilations and supporting material will be submitted for review by a GEBCO approval panel which will comprise the compiler and two independent experts. The review team will report back to the GEBCO Officers.

Adherence to the above principles should ensure that, at any given time, a high quality, seamless global bathymetric chart of GEBCO basic contours can be output from the GDA. In general, it is envisaged that the geographic coverage of newly inserted compilations will normally (but not exclusively) be in excess of a minimum size of 5° by 5°, or its equivalent area. It is anticipated that compilations at the larger scales will include progressively increased numbers of intermediate contours, possibly with intervals as small as 20m at the largest scale. The contour interval will, in general, be governed by the sounding density and the smoothness of the topography. The use of digital techniques will enable seafloor relief to be stored at high resolution where appropriate, without compromising the facility to produce smaller scale seamless charts of the GEBCO basic contours. It is planned that the generalisation of larger scale compilations being input into the GDA will be kept to minimum so as to avoid loss of information.

The GDA is updated and maintained at the British Oceanographic Data Centre (BODC) by the GDA Manager, Pauline Weatherall. As each new compilation is received, careful checks are made on the quality of digitization including contour labelling, geographic registration, and conformance with any hard copy charts that may have been published from the compilation. Checks are also made against the GEBCO shorelines and any necessary editing is carried out interactively. If material is received in hard copy form, it is raster scanned externally and then vectorized at BODC. In merging new sheets into the GDA, careful attention is paid to edge-matching the basic GEBCO contours (i.e. 200m, 500m, and 500m intervals thereafter) across the boundaries of the sheets into the surrounding GDA bathymetry so as to maintain a seamless global bathymetry. Adjustments are made as necessary, taking due account of the underlying trackline control information. Intermediate contours are only edge-matched if present on both sides of the boundary. No attempt is made to edge-match tracklines crossing the boundaries – a mismatch of tracklines between sheets usually occurs when sheets compiled at different scales are joined and reflects differences in geographic registration accuracy.

ANNEX J

Digitization of the IBCM (First Edition)

INTERNATIONAL BATHYMETRIC CHART OF THE MEDITERRANEAN

Published in 1981 by the Head Department of Navigation and Oceanography, St. Petersburg, Russia on behalf of the IOC.

The IBCM project was conceived in 1972 by participants in the joint IOC/ICSEM/FAO Programme of Cooperative Investigations in the Mediterranean (CIM) and was coordinated by the IOC/ICSEM/FAO Operational Unit for CIM in Monaco. The work was progressed from 1974 to 1978 under the guidance of an 'Ad-hoc Group of Experts on Bathymetric Charts of the Mediterranean'. This group was subsequently reshaped into the 'IOC Editorial Board for the IBCM'.

One of the principles adopted in the preparation of IBCM was to accept only precision soundings, with accurate navigation by satellite or comparable techniques, read from echo-sounder records corrected for the speed of sound. Most of the data selected were navigated using Loran C, with the positional accuracy varying from +/-100m in central areas (e.g. the Tyrrhenian Sea) to +/-600m in peripheral areas. The soundings were compiled on 1:250,000 British Admiralty plotting sheets for oceanic soundings, and the contours were drawn directly on these sheets before being reduced to 1:1 million. The contours were drawn by scientists specialised in morphology and charting of the sea floor.

The bulk of the data available for the IBCM First Edition was collected on marine geophysical surveys undertaken by three institutions. Between 1961 and 1965, 112,000 km of track were surveyed by the Osservatorio Geofisico Sperimentale (OGS) of Trieste in cooperation with the Saclant ASW Research Centre in La Spezia. Then, between 1965 and 1972, the OGS acquired another 217,500 km of track, primarily in the western and central Mediterranean but also including a reconnaissance of the eastern Mediterranean. In the eastern Mediterranean, east of 20°E, the Department of Geodesy and Geophysics of Cambridge University carried out a regional bathymetric survey with another 220,000 km of track. These 550,000 km of track comprised 80% of all the data available for the First Edition of the IBCM.

The cartography of the First Edition of IBCM was carried out by the Head Department of Navigation and Oceanography, St. Petersburg and they published the complete series in 1981 under the auspices of the IOC. It consists of 10 sheets on Mercator projection at a scale of 1:1 million (at 38°N) and covers an area 30°N to 46°N; 6°W to 36.5°E. The Black Sea is included at a scale of 1:2 million for the area 40°N to 47.5°N; 26.5°E to 42.5°E. Most sheets depict contoured bathymetry at 0m(coastline), 20m, 50m, 100m, and 200m, and at 200m intervals thereafter, although the actual contours displayed vary slightly from sheet to sheet. The published sheets also include land contours as well as sounding control showing the position of echo-sounding tracks and areas of detailed surveys.
The IBCM coastline was taken from the original bathymetric plotting sheets, except for Corsica, Sardinia and the area of Alexandria, where the coastline shown on the plotting sheets differed significantly from that on the nautical charts and topographic charts available at the time IBCM was in preparation. The coastline was taken from the latter for these areas.

In 1983, the bathymetric contours and coastlines depicted on the IBCM First Edition were digitised by a commercial company from polyester transparencies of the ten 1:1 million master sheets. The digitisation was carried out by manual curve following on a digitising

table, according to the specification that a) ninety percent of the digitised points should fall within 0.3mm of their position on the source map, with no point to exceed 1.0mm from that position and b) the maximum distance between successive digitised points should be 1.0mm.

In 1988, a detailed review and editing of the digitised data was carried out by the British Oceanographic Data Centre on behalf of the IOC. After removal of some minor digitising errors, the review confirmed that, in general, the digitisation accuracy was within the line thickness (0.3mm) of the plotted out digitised contours. The standard of digitisation of the 1:2 million chart of the Black Sea was found to be slightly inferior to that of the other sheets, although still within 1 chart mm.

All bathymetric contours and coastlines present on the published sheets are included in the digital data set where they are expressed in vector form in geographic coordinates. The digitised data set does not include the land contours or the underlying track control information.

ANNEX K

Supporting Documentation for Bathymetric Charts used to update the GEBCO Digital Atlas

This Annex contains the supporting documentation to accompany the nine charts used to update GEBCO in the Centenary Edition of the GEBCO Digital Atlas.

Annex K.1: Sheet G.01 - Arctic Ocean

Annex K.2: Sheet G.02 - North-east Atlantic off the British Isles

Annex K.3: Sheet G.03 - Caribbean Sea and the Gulf of Mexico

Annex K.4: Sheet G.04 - North-east Atlantic off the Iberian Peninsula

Annex K.5: Sheet G.05 - Mid Atlantic Ridge to North-west Africa

Annex K.6: Sheet G.06 - Central Eastern Atlantic

Annex K.7: Sheet G.07 - Weddell Sea and the Bransfield Strait

Annex K.8: Sheet G.08 - Greater Indian Ocean

Annex K.9: Sheet G.09 - Waters around New Zealand

ANNEX K.1: GEBCO Sheet G.01

(Arctic Ocean)

INTERNATIONAL BATHYMETRIC CHART OF THE ARCTIC OCEAN (IBCAO)
(Contours computed from Version 1.0 of the IBCAO grid dated July 2001)

Authors: Martin Jakobsson, University of New Hampshire, USA; Norman Cherkis, Five Oceans Consultants, USA (formerly of the US Naval Research Laboratory); John Woodward, Royal Danish Administration of Navigation and Hydrography; Ron Macnab, Geological Survey of Canada; and Bernard Coakley, University of Alaska Fairbanks, USA.

Contributions by Members of the IBCAO Editorial Board:

Jennifer Harding, Geological Survey of Canada; Hans-Werner Schenke and Martin Klenke, Alfred Wegener Institute, Germany; Hilmar Helgason, Icelandic Hydrographic Service; Harald Brekke and Morten Sand, Norwegian Petroleum Directorate; Valery Fomchenko, Head Department of Navigation and Oceanography, Russia; Garrik Grikurov and Sergei Maschenkov, VNIIOkeangeologia, Russia; and David Divins, National Geophysical Data Center, USA.

Sheet limits: 64°N to 90°N; 180°W to 180°E

Horizontal Datum: WGS-84

Scale: Contours derived from a 2.5km by 2.5km bathymetric grid in polar stereographic projection co-ordinates

Contour Units: Bathymetric depth in corrected metres

Contours present: 20m, 50m, 100m, 150m, 200m, 300m, 400m, 500m and at 500m intervals thereafter down to 5500m. Additional contours at 100m intervals from 500m to 3400m are also present in southern boundary region between 95°W and 5°E.

Coastline Source: NIMA World Vector Shoreline (1:1 million scale) except for the coast of Greenland and northern Ellesmere Island where an updated coastline was provided by the National Survey and Cadastre, Denmark (KMS).

Reference: Jakobsson, M., N.Z. Cherkis, J. Woodward, R. Macnab and B. Coakley (2000). New grid of Arctic bathymetry aids scientists and mapmakers, Eos, Transactions, American Geophysical Union, v.81, no.9, p.89, 93, 96

PREPARATION OF GEBCO SHEET G.01

The bathymetric contours for sheet G.01 were derived from version 1.0 (dated July 2001) of the IBCAO gridded bathymetric data set produced at intervals of 2.5km by 2.5km in polar stereographic projection co-ordinates and submitted to BODC by Martin Jakobsson. The grid was based on an extensive database of soundings collected in the region from a variety of

sources as listed below. In regions of sparse soundings, these data were augmented with contour information as follows:

In the central Arctic Ocean, data were incorporated from a newly published Russian map (HDNO et al., 1999) while information was extracted from an earlier NRL chart (Perry et al., 1986) for the area of Bering Strait. Similarly, contour information was taken from NRL maps (Cherkis et al., 1991; Matishov et al., 1995) in the Barents and Kara Seas. In the southern Norwegian-Greenland Seas, Baffin Bay and parts of the Canadian Arctic reference was made to the digital version of GEBCO sheet 5.17. Bathymetry in the Gulf of Bothnia was derived from a 2'(E-W) by 1'(N-S) digital grid compiled by Seifert and Kayser (1995). On the continental shelf of Siberia in the Laptev and East Siberian Seas and the Kara Sea (east of 80°E), soundings were extracted from a suite of navigational charts published by the Russian Head Department of Navigation and Oceanography (HDNO, 1989-1998). These soundings were used to manually draw contours (at intervals of the order of 5m) which were subsequently digitised for input to the grid. Where no contour information was available in data sparse areas e.g. around Greenland, provisional contours were prepared by the IBCAO group to facilitate the gridding process.

All data were imported to Intergraph's GIS system MGE (Modular GIS Environment) with projection parameters set to polar stereographic on the WGS-84 ellipsoid, with a true scale at 75°N. The data were corrected for sound velocity using Carter's Tables or CTD profiles where available, and colour-coded by depth value to facilitate a visual inspection of outliers, cross-track errors and the fit between contours and sounding data. Suspicious soundings were removed, and where contours showed major discrepancies with the soundings, the contours were manually adjusted to fit the new trackline data.

All data were then exported to an XYZ co-ordinate system for further processing and for gridding using the GMT public domain software. Prior to gridding, the data were pre-processed with a block-median filter in GMT. Gridding at a cell size of 2.5 x 2.5km was performed with the 'surface' program, fitting a surface of continuous curvature to all points. Three-dimensional visualization of the gridded data highlighted discrepancies that had to be resolved in the input data set, after which the data were re-gridded and re-inspected for residual discrepancies. This process was continued until the results were deemed satisfactory.

For the creation of GEBCO sheet G.01, contours were generated from the 2.5 x 2.5km grid using Z/I Imaging's tool Modular GIS Environment (MGE) Terrain Analyst (MTA). A cubic parametric curve was fitted through the generated contours for removal of minor deviations along the contour lines. The contour nodes were then converted from polar stereographic co-ordinates to geographic latitude and longitude co-ordinates. The bathymetric contour data set was filtered to cut down on the volume of points using the Douglas-Peucker algorithm. This data set was then submitted to BODC for inclusion in the GEBCO Digital Atlas.

Final editing of the contour data set to remove any small artefacts that were generated during the gridding process was carried out at BODC by Norman Cherkis in July 2001. He was also responsible for edge-matching the contours with adjacent sheets in the GEBCO Digital Atlas. The digital coastline data sets were also added to the contour data set at BODC. Trackline control information was provided by Martin Jakobsson in the form of a digital file containing the position of sounding points in the IBCAO database.

DATA SOURCES

Echo-sounding data archives of US National Geophysical Data Centre, US Naval Research Laboratory, Canadian Hydrographic Service and Royal Danish Administration of Navigation and Hydrography

US Navy and British Royal Navy submarine cruises 1957-88

Multibeam data collected by Norwegian Petroleum Directorate

Multibeam data from RV Polarstern 1990, 1994, 1995, 1997

Swedish ice-breaker Oden cruises 1991,1996

US SCICEX project, single beam bathymetry, six submarine missions 1993-1999

Canadian Hydrographic Service (1979), GEBCO Sheet 5.17, map, scale 1:6,000,000

Cherkis, N.Z., H.S. Fleming, M.D. Max, P.R. Vogt, M.F. Czarnecki, Y. Kristoffersen, A. Midthassel and K. Rokoengen (1991). Bathymetry of the Barents and Kara Seas. Geological Society of America Map and Chart Series, MCH047, scale 1:2,313,000, 1 sheet.

Head Department of Navigation and Oceanography, All-Russian Research Institute for Geology and Mineral Resources of the World Ocean, and Russian Academy of Sciences (1999). Bottom relief of the Arctic Ocean. Head Department of Navigation and Oceanography, St. Petersburg, map, scale 1:5,000,000, 1 sheet.

Head Department of Navigation and Oceanography (1989-1998) Hydrographic Charts: 11139, 11140, 11142, 11143, 11150, 11152, 11155, 12230, 12334, 12335, 12344, 12348, 12401, 12404, 12407, 12417, 12428, 12433, 13317, 13410, 13420, 13421, 13425, 13426, 13432, 14305, 14321, 14403, 14404, 14411, 14420, 14421, 14427, 14433, 14434, 15430, 16442, 18330, 19448, 19453, 698, 948-955; scales from 1:10,000 to 1:700,000.

Matishov, G.G., N.Z. Cherkis, M.S. Vermillion and S.L. Forman (1995). Bathymetry of the Franz Josef Land Area. Geological Society of America Map and Chart Series, MCH080, scale 1:500,000, 1 sheet.

Perry, R.K., H.S. Fleming, J.R. Weber, Y. Kristoffersen, J.K. Hall, A. Grantz, G.L. Johnson, N.Z. Cherkis and B. Larsen (1986). Bathymetry of the Arctic Ocean. Geological Society of America Map and Chart Series, MC-56, scale 1:4,704,075, 1 sheet.

Siefert, T. and B. Kayser (1995). A high resolution spherical grid topography of the Baltic Sea. Meereswissenschaftliche Berichte/Marine Science Reports, Institut fur Ostseeforschung, Warnemunde, Germany

Please note that version 2.23 of the IBCAO was released in March 2008 and can be accessed from: http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html

ANNEX K.2: GEBCO Sheet G.02
(NE Atlantic off the British Isles)

BATHYMETRY OF THE NORTH-EAST ATLANTIC OFF THE BRITISH ISLES (compiled February 1997 and originally published as sheet 97.3 in the 1997 release of the GEBCO Digital Atlas.)

(Minor update note: The bathymetry between 47°N and 48°N in the regions 11.5-13°W and 0-7.5°W has been replaced by revised bathymetry from GEBCO sheet G.04)

Author:	Sheet assembled by Peter M. Hunter, Southampton Oceanography Centre, U.K. from bathymetric charts compiled at the Institute of Oceanographic Sciences, Wormley, Surrey, U.K. (Note: The Institute of Oceanographic Sciences laboratory at Wormley was relocated to the Southampton Oceanography Centre in 1995)
Sheet Limits:	47°N to 64°N; 37°W to 6°E
Scale:	Contours compiled and digitised at a scale of 1:1 million but up to 1:250,000 in certain limited areas.
Horizontal Datum:	WGS-84
Contour Units:	Bathymetric depths in corrected metres
Contours present:	100m intervals throughout the area of the sheet down to a maximum contour depth of 5000m. Contours at 50m intervals on Rockall Bank.
Coastline Source:	NIMA World Vector Shoreline at a scale of 1:1 million
Digitised by:	NERC Experimental Cartography Unit, British Oceanographic Data Centre and the Southampton Oceanography Centre

BASE MAP FOR GEBCO SHEET 97.3 (G.02)

The base map for Sheet 97.3 was taken from source material used in the production of two charts of the Northeast Atlantic compiled by geoscientists at the Institute of Oceanographic Sciences, Wormley, Surrey and published by the UK Hydrographic Office, Taunton:

Admiralty Chart C6566: Bathymetry of the northeast Atlantic (Sheet 1) - 'Reykjanes Ridge and Rockall Plateau' by A.S. Laughton, D.G. Roberts & P.M. Hunter published in February 1982 and covering the area (47° to 64°N, 13° to 37°W). Hereafter referred to as IOS Sheet 1.

Admiralty Chart C6567: Bathymetry of the northeast Atlantic (Sheet 2) - 'Continental Margin around the British Isles' by D.G. Roberts, P.M. Hunter & A.S. Laughton published in February 1977 and covering the area (47° to 64°N, 6°E to 18°W). Hereafter referred to as IOS Sheet 2.

Both charts were published on Mercator projection at a scale of 1:2.4 million at 41°N. A discussion on the morphology of the area covered by the second sheet may be found in Roberts, D.G., Hunter, P.M. & Laughton, A.S. (1979) Deep Sea Research, 26A, p.417-428.

The contours for these charts were compiled by hand on 1:1 million scale compilation sheets using the GEBCO Collected Oceanic Soundings Sheets maintained by the UK Hydrographic Office and the Deutsches Hydrographisches Institut as the principal source of soundings. Additional sources included the GEBCO collection of the Service Hydrographique et Oceanographique de la Marine, France and soundings sheets compiled by the US Naval Oceanographic Office and the US Defense Mapping Agency. Soundings in plotted or computer-compatible form were also made available by:

Institute of Oceanographic Sciences, UK
Bedford Institute of Oceanography, Canada
Department of Geodesy & Geophysics, Cambridge University, UK
Department of Geology, Durham University, UK
Lamont-Doherty Geological Observatory, USA
Shirshov Institute of Oceanology, Russia
Woods Hole Oceanographic Institution, USA

The contours were produced at 100m intervals with the soundings corrected according to Matthews' Tables. Interpolation of contours between sounding lines was based on a geological interpretation of the available data. The two published charts were prepared by automatic cartographic techniques developed by NERC's Experimental Cartography Unit. Prior to publication, the hand drawn contours on the 1:1 million compilation sheets were digitised and stored as labelled streams of coordinates. These were subsequently recovered by BODC and, after careful checking and editing, were used as the basis for constructing GEBCO Sheet 97.3. The trackline control was redigitised by BODC from raster scanned images of the 1:1 million compilation sheets - on the continental shelf, tracklines are only available in the vicinity of the shelf edge.

DETAILED SURVEYS INCORPORATED INTO GEBCO SHEET 97.3 (G.02)

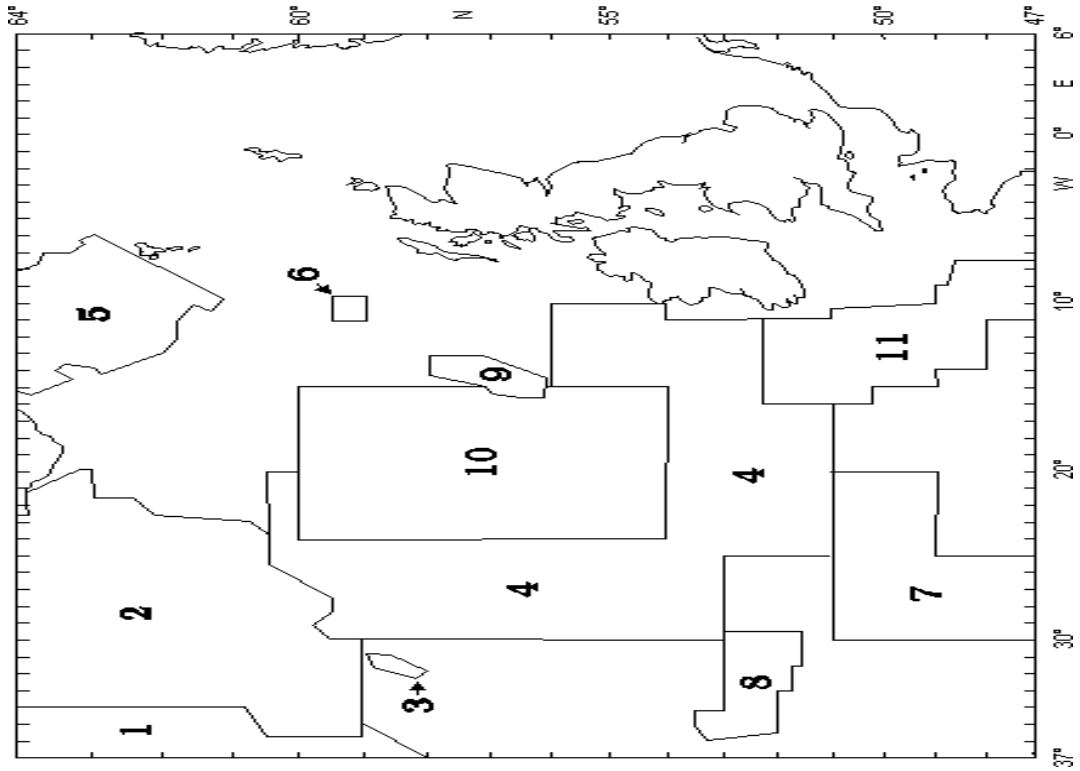
GEBCO Sheet 97.3 includes bathymetry from eleven detailed survey/special study areas, the origins of which are described below. The digitised contours for areas 1 to 7 were already present in the data set produced for IOS Sheets 1 and 2 but without corresponding trackline control information. However, for areas 8 and 9, the contours were digitised from higher scale source material while the contours in areas 10 and 11 are based on updated bathymetry compiled subsequent to the publication of IOS Sheets 1 and 2.

AREA 97.3-01 IRMINGER BASIN

Contours extracted from bathymetric chart produced by the US Naval Oceanographic Office and the Deutsches Hydrographisches Institut. Based primarily on echo-soundings from cruises of USNS Lynch in summer 1972 and autumn 1973 and earlier cruises of Meteor. The scale of the original chart is not documented and the trackline control information is missing.

Reference: Johnson, G.L., Sommerhoff, G. & Egloff, J. (1975) Structure and morphology of the west Reykjanes basin and the southeast Greenland continental margin. Marine Geology, 18(3), p.175-196.

Geographic coverage of GEBCO Sheet 97.3 and location of special survey areas



AREA 97.3-02 REYKJANES RIDGE (NORTH)

Contours interpolated from unpublished bathymetric chart compiled by G.L. Johnson of the US Naval Oceanographic Office in the late 1960s. Original chart was on Mercator projection scaled at 2 inches per degree longitude (approx. 1:1 million) with a contour interval of 100m (uncorrected). The chart was recontoured at intervals of 100m(corrected) with the contours and trackline control then being transcribed onto the 1:1 million compilation sheets maintained at the Institute of Oceanographic Sciences, Wormley, UK. Later digitised for inclusion in GEBCO Sheet 97.3.

AREA 97.3-03 REYKJANES RIDGE CREST SURVEY

RRS Discovery cruise 84, 1977, unpublished survey by the Institute of Oceanographic Sciences, Wormley, UK. The area was fully surveyed by side scan sonar using the long range (30km) double sided sonar of GLORIA Mk II and a hull mounted medium range (2.5km) sonar. Transects of the ridge were made at intervals of 14km. Narrow beam echo-soundings were taken on all tracks. The tracklines and 100m (corrected) interval contours were transcribed from the survey sheets onto 1:1 million compilation sheets. Later digitised for inclusion in GEBCO Sheet 97.3.

Reference: Laughton, A.S., Searle, R.C. & Roberts, D.G. (1979) The Reykjanes Ridge crest and the transition between its rifted and non-rifted regions. Tectonophysics, 55, p.173-177

AREA 97.3-04 OCEAN BASINS AROUND ROCKALL PLATEAU

Contours interpolated from unpublished fair drawn bathymetric chart on Mercator projection scaled at 2 inches per degree longitude (approx. 1:1 million) and with a contour interval of 100 fathoms (uncorrected). Chart produced by the US Naval Oceanographic Office based on

a comprehensive echo-sounding survey in the late 1960s consisting of a series of east-west tracks spaced less than 10km apart throughout the area. Recontoured at intervals of 100m (corrected) onto 1:1 million scale compilation sheets maintained at the Institute of Oceanographic Sciences, Wormley, UK and later digitised for inclusion in GEBCO Sheet 97.3. The tracklines were not included on the original chart - the sounding data east of 20°W were later published on CDROM by the US National Geophysical Data Center, Boulder and the relevant tracklines have been extracted from the CDROM for inclusion in GEBCO Sheet 97.3.

References: Johnson, G.L., Vogt, P.R. & Schneider, E.D. (1971) Morphology of the Northeastern Atlantic and Labrador Sea. Deutsche Hydrographische Zeitschrift, 24(2), p.49-73

Johnson, G.L. & Schneider, E.D. (1969) Depositional ridges in the North Atlantic. Earth & Planetary Science Letters, 6(6), p.416-422

AREA 97.3-05 ICELAND - FAROE RISE

Extracted from 'Faroes - Iceland Ridge Topographic Map (Ed. K. Vollbrecht)' produced in 1973 by the Deutsches Hydrographisches Institut at a scale of 1:500,000 on Mercator projection. Based on a detailed survey. Contoured at intervals of 100m (corrected) but sometimes at intervals of 20m and occasionally at 10m intervals. The 100m interval contours and trackline control were transcribed onto 1:1 million compilation sheets maintained at the Institute of Oceanographic Sciences, Wormley, UK. Later digitised for inclusion in GEBCO Sheet 97.3.

Reference: Fleischer, U., Holzkamm, F., Vollbrecht, K. & Voppel, D. (1974) Die Struckur des Island-Faroer-Ruckens aus geophysikalischen Messungen. Deutsche Hydrographische Zeitschrift, 27(2), p.97-113

AREA 97.3-06 ROSEMARY BANK

Based on unpublished survey of Rosemary Bank by HMS Hecate in 1967 (UK Hydrographic Office) consisting of east-west tracks at a spacing of 4.6km but with a spacing of 2.3km over the Bank and 1.2km over the crest of the Bank. Survey sheet was compiled on Mercator projection at a scale of 1:200,000 with soundings plotted out in fathoms (uncorrected). Sheet was contoured at intervals of 100m (corrected) and transcribed onto 1:1 million compilation sheets maintained at the Institute of Oceanographic Sciences, Wormley, UK. Tracklines digitised from original survey sheet.

AREA 97.3-07 MID-ATLANTIC RIDGE (47° to 51°N)

Interpolated from unpublished fair drawn bathymetric chart on Mercator projection scaled at 1.25 inches per degree longitude (approx. 1:2 million) and with a contour interval of 100 fathoms (uncorrected). Chart produced by the US Naval Oceanographic Office based on a comprehensive echo-sounding survey in the late 1960s consisting of a series of east-west tracks spaced less than 10km apart throughout the area. The chart was recontoured at intervals of 100m (corrected) and transcribed onto 1:1 million compilation sheets maintained at the Institute of Oceanographic Sciences, Wormley, UK. The tracklines were not available on the original chart.

Reference: Johnson, G.L. & Vogt, P.R. (1973) Mid-Atlantic Ridge from 47° to 51° North. Geological Society of America Bulletin, 84, p.3443-3462

AREA 97.3-08 ACTIVE PART OF CHARLIE-GIBBS FRACTURE ZONE

Digitised from unpublished 1:250,000 scale bathymetric chart compiled by the Institute of Oceanographic Sciences, Wormley, UK in 1978. Bathymetric interpretation relies heavily on a side-scan sonar survey (RRS Discovery Cruise 84: June-July 1977) using the long range (30km) double sided sonar of GLORIA Mk II and a hull mounted medium range (2.5km) sonar. The sonar coverage was not completely overlapping. Chart compiled at a contour interval of 100m (corrected) using RRS Discovery cruise 84 echo-soundings in conjunction with soundings from HMS Hecate (UK Admiralty), USNS Gibbs (US Naval Research Laboratory, Washington), NO Jean-Charcot (Centre Oceanologique de Bretagne, Brest) and RV Cirolana (Fisheries Laboratory, Lowestoft). Ship tracks were adjusted within the limits of the navigation systems used (Loran C and transit satellites) to bring soundings in line with the physiographic features seen on the GLORIA records.

Reference: Searle, R.C. (1981) The active part of Charlie-Gibbs Fracture Zone: a study using sonar and other geophysical techniques. Journal of Geophysical Research, 86, p.243-262

AREA 97.3-09 ROCKALL BANK

Interpolated from Admiralty Chart C6091 published by UK Hydrographic Department, Taunton at a scale of 1:250,000 with depths contoured at 5 fathom (corrected) intervals. Based on detailed survey, carried out by HMS Hecla in 1969, consisting of regular east-west bathymetric transects of the Bank with a spacing of 2.75km, but with 1.4km line spacing in areas of rough bottom topography with depths less than 100 fathoms and a 0.7km line spacing in the immediate vicinity of Rockall Islet. Navigated by Loran-C with estimated fix accuracy of +/-200m. For inclusion in GEBCO Sheet 97.3, the published chart was recontoured at intervals of 50m (corrected) and then digitised at a scale of 1:500,000. The tracklines were digitised from a 1:1 million scale chart in the reference below.

Reference: Roberts, D.G. & Jones, M.T. (1978) A bathymetric, magnetic, and gravity survey of the Rockall Bank by HMS Hecla 1969, Admiralty Marine Science Publication No. 19, Hydrographic Department, Taunton

AREA 97.3-10 ROCKALL PLATEAU

Contours were digitised directly from an unpublished bathymetric chart compiled in 1996 by P.M. Hunter of the Southampton Oceanography Centre, UK. The chart was compiled on Mercator projection at a scale of 1:1 million with contours drawn at intervals of 100m (corrected). Based primarily on single beam soundings available on the GEODAS (Version 3) CDROM published in June 1995 by the US National Geophysical Data Center, Boulder (IHO Data Centre for Digital Bathymetry). Contours were drawn to be consistent with the morphology of the region - in sparsely sounded areas, the compilation was supplemented with contours taken from IOS Sheet 1 which was assumed to be based on older (and less accurate) data. Contours between 54° and 56°N rely heavily on the 10km spaced east-west tracks surveyed by the US Naval Oceanographic Office in the late 1960s - east of 20°W these data were available on the GEODAS CDROM; only a precontoured chart without trackline control was available from this survey west of 20°W. Digital tracklines were taken directly from the GEODAS CDROM and supplemented by the tracklines previously digitised from IOS Sheet 1.

AREA 97.3-11 CONTINENTAL MARGIN - SOUTHWEST APPROACHES TO THE BRITISH ISLES

Source: Unpublished series of bathymetric charts compiled by P.M. Hunter in collaboration with colleagues at the Institute of Oceanographic Sciences (IOS), Wormley and the Centre Oceanologique de Bretagne (COB), Brest. Compiled on Mercator projection at a scale of 1:250,000 (at 38°N) with contours at intervals of 100m (corrected). The charts were compiled over the period 1984 to 1993 and the primary data source was the extensive coverage of Seabeam multibeam echo-sounder data (16 adjacent narrow beams within a swathe width below track of approximately two-thirds of the water depth) collected on NO Jean-Charcot and GLORIA Mark II scanning sonar image data (maximum scanning range of 30km either side of ship's track) from RRS Discovery. Contours and tracklines were digitised directly from these charts for incorporation into GEBCO Sheet 97.3. The area comprises four major sub-areas:

SUB-AREA A: Porcupine Seabight and Porcupine Bank (North of 49°30'N)

Compiled by P.M. Hunter (IOS) and N.H. Kenyon (IOS) in 1984 using:

a) original echo-sounding chart records from all IOS cruises crossing the region since 1966. In addition to depths, the positions of breaks of slope, canyon axes, ridge crests and other features were extracted from the records.

b) NC Marcel Bayard survey for the CANTAT II telephone cable (M.T. Jones (IOS))

c) Seabeam data covering the Goban Spur, the outer edge of the Porcupine Bank and the Gollum Channel system in the Seabight; collected during the Norestlante 1 cruise of NO Jean-Charcot in 1983 (J.C. Sibuet (COB))

d) GLORIA records from RRS Discovery cruise 83 covering the channel system in the Seabight, northern edge of Goban Spur and southern edge of Porcupine Bank

e) East-west sounding tracks at spacing of 10km taken by USNS Sgt. Curtis F. Shoup north of 51°N (US Naval Oceanographic Office)

SUB-AREA B: Goban Spur (48°-49°30'N; 11°-14°W)

Compiled by P.M. Hunter (IOS) and J.C. Sibuet (COB) in 1983. Based on Seabeam coverage over about two thirds of the area by NO Jean-Charcot and complemented by GLORIA images parallel to the shelf break. Conventional single beam soundings were used to fill in gaps in Seabeam coverage.

Reference: Sibuet, J.C. et al. (1984) Morphology and basement structures of the Goban Spur continental margin and the role of the Pyrenean Orogeny. Initial Reports of the Deep Sea Drilling Project, Volume LXXX, p.1153-1165. Washington (US Government Printing Office)

SUB-AREA C: (47°-49°N; 9°-11°W)

Compiled by P.M. Hunter (IOS) in 1993. Based on conventional echo-soundings supported by almost complete GLORIA imagery over the shelf break north of 48°N. Good Seabeam coverage in the east and a few Seabeam tracks elsewhere - supplied by L. Pastouret (COB) and J.C. Sibuet (COB).

Reference: Pastouret, L., Beuzart, P. & Monti, S. (1982) Presentation de cartes bathymetriques de la marge continentale armoricaine et celte, golfe de Gascogne. Bulletin de la Societe Geologique de France, 24, p.407-411

SUB-AREA D: Meriadzek Terrace (47°-48°N; 7°30'-9°20'W)

Based on a detailed GLORIA survey carried out by RV Farnella in September 1984 complemented by conventional single beam echosoundings. Seabeam data were available over the canyon areas - supplied by L. Pastouret (COB) and J.C. Sibuet (COB).

Reference: Kenyon, N.H. & Hunter, P.M. (1985) A long-range side-scan sonar survey of the Meriadzek Terrace, Bay of Biscay. Institute of Oceanographic Sciences Report No. 20, 17pp.

ANNEX K.3: GEBCO Sheet G.03

(Gulf of Mexico and the northern Caribbean Sea)

INTERNATIONAL BATHYMETRIC CHART OF THE CARIBBEAN SEA AND THE GULF OF MEXICO (IBCCA)

The bathymetry of this sheet is taken from sheets 1.01 to 1.09 of the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico(IBCCA) compiled under the guidance of the IOC Editorial Board for IBCCA (Chief Editor: Mario Alberto Reyes Ibarra, INEGI). Bathymetry for these IBCCA sheets was completed in the period 1997 to 2001 while the data sets were submitted to BODC in 2002.

Authors (Scientific Coordinators):

IBCCA Sheets 1.01 to 1.04 and 1.09 compiled by the US National Geophysical Data Center (NGDC) (Troy L. Holcombe);

IBCCA Sheets 1.05 and 1.06 compiled by Instituto Nacional de Estadistica, Geografia e Informatica (INEGI), Mexico (Jose Luis Frias Salazar);

IBCCA Sheets 1.07 and 1.08 compiled by Agencia de Cartografia Nautica, Cuba (Rolando Feito Sarduy)

Sheet Limits: 15°N to 33°N; 101°W to 69°W (and to 61°W from 15°N to 24°N)

Limits of individual IBCCA Sheets:

24°-33°N, 101°-93°W(1.01); 93°-85°W(1.02); 85°-77°W(1.03); 77°-69°W(1.04)

15°-24°N, 101°-93°W(1.05); 93°-85°W(1.06); 85°-77°W(1.07); 77°-69°W(1.08); and 69°-61°W(1.09)

Scale: contours compiled and digitised on Mercator sheets at a scale of 1:500,000

Horizontal Datum: WGS-84

Contour Units: bathymetric depth in corrected metres

Contours present: standard contours at 0m, 20m, 40m, 60m, 80m, 100m, 200m, and at 200m intervals thereafter down to 8,400m. Also included as standard are contours at 500m and at 1000m intervals thereafter. Intermediate contours appear frequently on the sheets; thus many areas include contours at 100m intervals, and some areas include more frequent shallow water contours up to 200m. Some of the abyssal floor areas also have contours at 10m-20m intervals.

Coastline Source: NIMA World Vector Shoreline (full resolution)

Published Chart: For up to date information on IBCCA chart products please refer to website www.ngdc.noaa.gov/mgg/ibcca. Sheets 1.04 and 1.09 have already been published in hard copy form.

PREPARATION OF GEBCO SHEET G.03

The bathymetry of the individual IBCCA sheets was compiled and digitised on standard plotting sheets at a scale of 1:500,000. The digital contours for sheets 1.01 to 1.04 were submitted to BODC by Lisa Taylor of NGDC while the contours and trackline control for sheets 1.05 to 1.09 were submitted in digital form by Jose Luis Frias Salazar of INEGI. For sheets 1.01 to 1.04 the trackline control was provided in the form of a data source diagram – the tracklines and survey box outlines were digitised from this diagram by BODC.

In order to maintain seamless bathymetry at the standard GEBCO depths (i.e. 200m, 500m and at 500m intervals thereafter) checks were made by BODC to ensure conformation in the IBCCA contours, particularly at 500m, 1500m, 2500m etc (non-standard depths within IBCCA). Missing contours at these levels were interpolated by BODC with the aid of a gridded version of the bathymetry, followed by manual adjustment as appropriate, and included in the data set. As a result of this, about one third of the 500m, 1500m, 2500m etc contours on IBCEA Sheets 1.01 to 1.04 were generated by BODC with about two-thirds generated for Sheets 1.05 to 1.09.

For large areas of IBCCA sheets 1.01, 1.02, 1.03, 1.05 and 1.09, trackline control is shown in terms of survey boxes rather than as individual sounding points or tracklines. These are areas of high sounding density and occur particularly in the northern half of the Gulf of Mexico, around the Yucatan peninsula and the Atlantic seaboard off Florida. Further information on these survey areas may be found in the GEBCO Digital Atlas.

DATA SOURCES

IBCCA SHEET 1.01

Scientific Coordinator: Troy L. Holcombe (MGG, NGDC)

Compiler: Lisa A. Taylor (MGG, NGDC).

Digital soundings from the U.S. National Geophysical Data Center Global Trackline Geophysical Data Base (GEODAS). Collecting institutions include the Institute for Geophysics, University of Texas; Lamont-Doherty Earth Observatory of Columbia University; U. S. Coast Survey; and the U.S. Naval Oceanographic Office.

Sources of detailed surveys and bathymetric contours:

1. Soundings from surveys conducted by the U.S. National Oceanic and Atmospheric Administration/National Ocean Service/Coast Survey. Track spacing varies with depth:

    0.1 to 0.8 km track spacing for depths from 0 to 200 meters
    0.8 to 1.6 km track spacing for depths from 200 to 900 meters
    3.2 km track spacing for depths from 900 to 2750 meters
    8.0 km track spacing for depths over 2750 meters

Digital contours from the U. S. Geological Survey CONMAP data base, derived from U.S. Coast Survey 1:250,000 scale bathymetric maps, were used in some areas to fill in small data gaps.

2. Contours digitally generated from multibeam surveys conducted by the U.S. Coast Survey ships WHITING and MOUNT MITCHELL from 1988 to 1992.

3. Contours provided by William R. Bryant of Texas A & M University; from industry surveys compiled at a scale of 1:192,000. Track spacing from 0.45 to 0.9 km.

4. Multibeam data collected by R.V. Gyre

IBCCA SHEET 1.02

Scientific Coordinator: Troy L. Holcombe (MGG, NGDC)

Compiler: Lisa A. Taylor (MGG, NGDC).

Digital soundings from the U.S. National Geophysical Data Center Global Trackline Geophysical Data Base (GEODAS). Collecting institutions include the Institute for Geophysics, University of Texas; Lamont-Doherty Earth Observatory of Columbia University; U. S. Coast Survey; and the U.S Geological Survey.

Sources of detailed surveys and bathymetric contours:

1. Soundings from surveys conducted by the U.S. National Oceanic and Atmospheric Administration/National Ocean Service/Coast Survey. Track spacing varies with depth:

   0.1 to 0.8 km track spacing for depths from 0 to 200 meters
   0.8 to 1.6 km track spacing for depths from 200 to 900 meters
   3.2 km track spacing for depths from 900 to 2750 meters
   8.0 km track spacing for depths over 2750 meters

   Digital contours from the U. S. Geological Survey CONMAP data base, derived from U.S. Coast Survey 1:250,000 scale bathymetric maps, were used in some areas to fill in small data gaps.

2. Contours digitally generated from multibeam surveys conducted by the U.S. Coast Survey ships WHITING and MOUNT MITCHELL from 1988 to 1992.

3. Surveys conducted by the National Imagery and Mapping Agency (NIMA) ships BARTLETT and KANE from 1983 to 1985. Track spacing 1.8 km.

4. Contours digitally generated from a three arc second gridded five beam subset of multibeam surveys conducted by the Scripps Institution of Oceanography ship ATLANTIS II in 1986.

Imagery from the side-scanning sonar system (GLORIA-II), obtained by the U.S. Geological Survey, was employed in the interpretation of bathymetric contours along portions of the Florida Escarpment.

IBCCA SHEET 1.03

Scientific Coordinator: Troy L. Holcombe (MGG, NGDC)

Compiler: Lisa A. Taylor (MGG, NGDC).

Digital soundings from the U.S. National Geophysical Data Center Global Trackline Geophysical Data Base (GEODAS). Collecting institutions include the Woods Hole Oceanographic Institution; Lamont-Doherty Earth Observatory of Columbia University; U. S. Geological Survey; and the U.S. Naval Oceanographic Office.

Sources of detailed surveys and bathymetric contours:

1. Soundings from surveys conducted by the U.S. National Oceanic and Atmospheric Administration/National Ocean Service/Coast Survey. Track spacing varies with depth:

   0.1 to 0.8 km track spacing for depths from 0 to 200 meters

   0.8 to 1.6 km track spacing for depths from 200 to 900 meters

   3.2 km track spacing for depths from 900 to 2750 meters

   8.0 km track spacing for depths over 2750 meters

   Digital contours from the U. S. Geological Survey CONMAP data base, derived from U.S. Coast Survey 1:250,000 scale bathymetric maps, were used in some areas to fill in small data gaps.

2. U.S. Naval Oceanographic Office bathymetric contour sheet 805 (NA-9), scale 1:1,000,000, compiled by F.H. Sorenson in 1984 (100 meter contour approximated).

3. Surveys conducted by the U.S. Naval Oceanographic Office ships USS Sheldrake, USS Prevail and USS Pursuit from 1959 to 1964. Trackline spacing from 0.3 to 1.8 km.

4. Contours digitally generated from a three arc second gridded five beam subset of multibeam surveys conducted by the Scripps Institution of Oceanography ship ATLANTIS II in 1986.

Imagery from the side-scanning sonar system (GLORIA-II), obtained by the U.S. Geological Survey, was employed in the interpretation of bathymetric contours along portions of the Florida Escarpment.

IBCCA SHEET 1.04

Scientific Coordinator: Troy L. Holcombe (MGG, NGDC)

Compiler: Lisa A. Taylor (MGG, NGDC).

Sources of Bathymetric Data and Bathymetric Contours:

Numbers correspond to numbered areas shown on the printed chart.

1. U.S. National Oceanic and Atmospheric Administration/National Ocean Service surveys. (Track spacing for this area is 0.25 to 2.8 km)

2. U.S. National Oceanic and Atmospheric Administration/National Ocean Service surveys. (Trackline spacing for this area is 0.25 to 1.5 km)

3. U.S. Naval Oceanographic Office survey, trackline spacing 0.8 to 1.0 km. The survey was completed by the USS Prevail in 1962.

4. U.S. Naval Oceanographic Office survey, trackline spacing 0.8 to 1.0 km. The survey was completed by the USS Sheldrake in 1961.

Bathymetry for survey areas 1 and 2 was derived from surveys conducted between 1983 and 1984. Most of the surveys were conducted by the U.S. National Oceanic and Atmospheric Administration/National Ocean Service survey ship WHITING.

Tracklines shown for the remaining area are from:

- Digital data files of the U.S. National Geophysical Data Center. Primary sources include the U.S. Navy, Woods Hole Oceanographic Institution, Lamont Doherty Geological Observatory, Scripps Institution of Oceanography, U.S. Geological Survey and the Defense Mapping Agency.
- Random tracks from the U.S. Naval Oceanographic Office.
- Mid-Ocean Dynamics Experiment, MODE-I Region Bathymetry, Chart 1, at a scale of 1:500,000 compiled by Patricia A. Bush, published by the National Oceanic and Atmospheric Administration, National Ocean Service for the Environmental Research Laboratories, Atlantic Oceanographic and Meteorological Laboratories, 1976. (Tracks confined to the area 69° to 77°W, 26° to 29°N)
- Bathymetric chart of the Blake Escarpment at a scale of 1:1,000,000, Universal Transverse Mercator compiled by William P. Dillon of the U.S. Geological Survey (unpublished).

Imagery from the side-scanning sonar system (GLORIA-II), obtained by the U.S. Geological Survey for the Blake Escarpment was employed in interpretation of bathymetric contours. The GLORIA-II imagery was custom photographed to scale and provided by William P. Dillon of the U.S. Geological Survey.

U.S. Naval Oceanographic Office bathymetric contour sheet 805(NA-9), at a scale of 1:1,000,000 compiled by F.H. Sorensen in 1984, provided supplementary information in areas of sparse track control, particularly in the area of 24°N to 24°30'N, 74°30'W to 76°30'°W.

IBCCA SHEET 1.05

Scientific Coordinator: Jose Luis Frias Salazar (DGG, INEGI)

Compilers: Marcos Aguilar Benitez, Manuel Cruz Pineda (DGG, INEGI)

Digital soundings from the U.S. National Geophysical Data Center Global Trackline Geophysical Data Base (GEODAS).

Sources of detailed surveys and bathymetric contours:

1. (Southern area of the Bay of Campeche) Bathymetric contours taken from the 1:200,000 scale maps ‘Marbella’ and ‘Coatzacoalcos’ produced from Mexican Petroleum’s Marine Seismology Program. The spacing between sounding lines is approximately 4km.

2. (Survey off Pacific coast of Mexico) Soundings from surveys of the Middle America Trench, conducted by the University of Texas between 1977 and 1978 from the research vessel Ida Green and also from surveys conducted by Scripps Institution of Oceanography (University of California) from the research vessel Thomas Washington in 1972. The spacing between sounding lines is variable between approximately 2km and 4km.

The coastline is based on the US NIMA's World Vector Shoreline updated with data of the coastline generated from the cartographic series of Mexico (topographic maps at a scale of 1:250,000 scale) from the DGG of the INEGI.

IBCCA SHEET 1.06

Scientific Coordinator: Jose Luis Frias Salazar (DGG, INEGI)

Compilers: Marcos Aguilar Benitez, Manuel Cruz Pineda (DGG, INEGI)

Digital soundings from the U.S. National Geophysical Data Center Global Trackline Geophysical Data Base (GEODAS).

Sources of detailed surveys and bathymetric contours:

1. Soundings from surveys conducted by the University of Hawaii (SOEST) Hawaii Institute for Geophysics in 1989 from the research ship Moana Wave.

2. (Campeche Bank and west of Yucatan Basin) Soundings from marine geophysical surveys carried out by Oregon State University and the Navy Secretariat of Mexico in 1985 from the research ship Altair.

3. (Northern edge of Campeche Bank) Surveys carried out by the U.S. National Imagery and Mapping Agency (NIMA) between 1983 and 1985 from the research vessels Bartlett in the western section and Kane in the eastern section of this area. The spacing between sounding lines is 1.8km.

4. Bathymetric contours taken from the map by Jacobs et al. (Jacobs, C.L., Edgar, N.T., Parson, L.M., Dillon, W.P., Scanlon, K.M., and Holcombe, T. L. (1989). A revised bathymetry of the Mid-Cayman Rise and the Cayman trough using long-range side-scan sonar. Institute of Oceanographic Sciences, Deacon Laboratory, report no. 272, 11p., map).

The coastline is based on the US NIMA's World Vector Shoreline updated with data of the coastline generated from the cartographic series of Mexico (topographic maps at a scale of 1:250,000 scale) from the DGG of the INEGI.

IBCCA SHEETS 1.07 AND 1.08

Documentation not available at the time of going to press with the GEBCO Digital Atlas

IBCCA SHEET 1.09

Scientific Coordinator: Troy L. Holcombe (MGG, NGDC)

Compilers: Lisa A. Taylor, Jason Maddox, Robert Mandzi, Dan Metzger (MGG, NGDC)

Sources of detailed surveys and bathymetric contours:

(Numbers correspond to numbered areas shown on the printed chart)

1. U.S. Naval Oceanographic Office surveys, trackline spacing generally 1-10 km. Adapted from bathymetric contours by Joseph P. Flanagan, Joseph G. Gilg, Charles R. Jones, Francis L. Marchant, Robert R. Murchison, Jack H. Rebman, Lavern W. Snodgrass, Frederick H. Sorenson, and Joseph C. Whitney, compiled at

scale 1:1,000,000 and published by the National Oceanic and Atmospheric Administration 1980, Bathymetric Chart of the Caribbean, scale 1:2,500,000.

2. U.S. Naval Oceanographic Office surveys, trackline spacing 1-10 km. Adapted from bathymetric contours by James E. Matthews and Troy L. Holcombe, compiled at a scale of 1:1,000,000 and published at a scale of 1:2,000,000 in Matthews, J.E. and Holcombe, T.L., 1976, Regional Geological/ Geophysical Study of the Caribbean Sea (Navy Ocean Area NA-9), 1. Geophysical Maps of the Eastern Caribbean, U.S. Naval Oceanographic Office Reference Publication Rp-3.

3. U.S. Naval Oceanographic Office surveys, trackline spacing 1-10 km.

4. U.S. Naval Oceanographic Office surveys, trackline spacing 0.05 to 2 km.

   Bathymetry for survey areas 3 and 4 is adapted from bathymetric contours by Julian C. Cooey, 1978, in Structure and Stratigraphy of the Offshore Margin of the Dominican Republic, unpublished M.S. Thesis, University of Southern Mississippi.

5. U.S. National Oceanic and Atmospheric Administration/National Ocean Service surveys, trackline spacing 0.025 to 0.3 km.

6. U.S. National Oceanic and Atmospheric Administration/National Ocean Service surveys, trackline spacing 0.3 to 0.6 km.

7. U.S. National Oceanic and Atmospheric Administration/National Ocean Service surveys, trackline spacing 0.6 to 1.5 km.

   Bathymetry for survey areas 5, 6, and 7 is derived from 159 surveys conducted between 1900 and 1988. Most of the surveys were conducted between 1968 and 1988 by the U.S. National Oceanic and Atmospheric Administration/National Ocean Service survey ships PEARCE, WHITING, and MONT MITCHELL. Locally these surveys were supplemented by trackline bathymetry from the files of the U.S. National Geophysical Data Center.

8. Bathymetric Chart of the Eastern Caribbean at a scale of 1:1,000,000 compiled by P. Bouysse (1984), and published in Philippe Bouysse, Patrick Andreieff, Maryannick Richard, Jean-Claude Baubron, Alain Mascle, Rene-Charles Maury, and Denis Westercamp, 1985, Geologie de la Ride d'Aves et des Pentes Sous Marines du Nord des Petites Antilles, Documents du BRGM no. 93, 146 p., maps. In addition to the trackline shown, data from draft bathymetry at a scale of 1:100,000 west of Guadaloupe from the Atlantic Oceanogaphic Mission (B.H. d'Entrecasteaux, Service Hydrographique et Oceanographique de la Marine), contributed in 1981 by H. Got of the University of Perpignan, as well as miscellaneous navigation charts of the Hydrographic Offices of France, U.S.A. and the United Kingdom for certain island plateaus and submarine banks of the Lesser Antilles and the Anegada Passage, were used in the compilation of this area.

8a. U.S. Naval Oceanographic Office surveys, trackline spacing 1-10 km. Adapted from bathymetric contours by James E. Matthews and Troy L. Holcombe, compiled at a scale of 1:1,000,000 and published at a scale 1:2,000,000 in Mathews, J.E. and Holcombe, T.L., 1976, Regional Geological/Geophysical Study of the Caribbean Sea (Navy Ocean Area N.A.-9). 1. Geophysical Maps of the Eastern Caribbean, U.S. Naval Oceanographic Office Reference Publication RP-3.

8b. Multibeam surveys from the ARCANTE 2 - THERMOSITE expedition, published in Bouysse, P., Robert, S., Guennoc, P. and Monti, S., 1963. Bathymetrie detaillee (seabeam) et anomalies magnetiques dans les Antilles Francaises, Documents du B.R.G.M., no 63, 78 p.

8c. Multibeam survey from the SEACARIB 1 expedition, R/V Conrad, 1985.

9. Bathymetric contours from Troy L. Holcombe, Cynthia G. Fisher, and Frederick A. Bowles,1989, Gravity-Flow Deposits from the St. Croix Ridge: Depositional History, Geomarine Letters, v.9, p.11-18. Trackline spacing ranges from 0.2km to 2 km.

Tracklines shown for the remaining area are from the digital data files of the U.S. National Geophysical Data Center. Trackline control from Matthews, J.E. and Holcombe, T.L. 1976, Regional Geological/Geophysical Study of the Caribbean Sea (Navy Ocean Area NA-9), 1. Geophysical Maps of the Eastern Caribbean, Naval Oceanographic Office Reference Publication RP-3, was also incorporated in the Venezuelan Basin area.

Imagery from the side-scanning sonar system (GLORIA-II), obtained by the U.S. Geological Survey for the areas shown in the inset map, was employed in interpretation of bathymetric contours. Published GLORIA-II images appear in: EEZ-SCAN 85 Scientific Staff (1987). Atlas of the U.S. Exclusive Economic Zone, Gulf of Mexico and Eastern Caribbean Areas, U.S. Geological Survey Miscellaneous Investigations Series I-1864-A, B. Additionally, tectonic sketches by Kathryn Scanlon based on GLORIA-II imagery in Masson, D.G. and Scanlon, K.M. (1991). The neotectonic setting of Puerto Rico, Geological Society of America Bulletin, v.103, p. 144-154, were used to interpret bathymetric contours.

Other reference information used in compilation was derived from the following publications:

Case, J.E. and Holcombe, T.L. (1980). Geologic-tectonic map of the Caribbean Region, U.S. Geological Survey Miscellaneous Investigations Series map no. I-1100.

Forsthoff, G.M. and Holcombe, T.L. (1987). Quaternary turbidities of the Muertos Trough, northeastern Caribbean Sea, composition, source and dispersal patterns, in Transactions of the Tenth Caribbean Geological Conference, Cartagena, p. 353-367.

McCann, W.R. and Sykes, L.R. (1984). Subduction of aseismic ridges beneath the Caribbean Plate, implications for the seismic potential of the northeastern Caribbean, Journal of Geophysical Research, v. 89, p. 4493-4519.

Ewing, M., Lonardi, A.G. and Ewing, J.I. (1965). The sediments and topography of the Puerto Rico Trench and Outer Ridge, in Transactions of the Fourth Caribbean Geological Congress, Trinidad, p. 325-334.

Tucholke, B.E. and Ewing, J.I. (1974). Bathymetry and sediment geometry of the Greater Antilles Outer Ridge and vicinity, Bulletin of the Geological Society of America, v. 85, p. 1789-1802.

Numbered source documents described above (except for items 5, 6, 7 and 9) were contoured in units of uncorrected metres. It was necessary to recontour in units of corrected metres using the echo sounding correction tables (3rd edition) published in 1980 by the Hydrographic Department of the British Admiralty.

ANNEX K.4: GEBCO Sheet G.04
(NE Atlantic off the Iberian Peninsula)

Sheet G.04 is a composite of three bathymetric compilations:

A. Bathymetric Chart of the Bay of Biscay, published in 1994, and compiled by Jean-Claude Sibuet, Serge Monti and Guy Pautot, Centre de Brest, Institut Francais de Recherche de l'Exploitation de la Mer (IFREMER), France

B. Sheet 1.01 of the International Bathymetric Chart of the Central Eastern Atlantic (IBCEA) published in February 2002 by the Instituto Hidrografico, Lisbon, Portugal. Scientific coordinator: Jean-Rene Vanney (Universites Pierre et Marie Curie et Paris-Sorbonne, France) in collaboration with Denis Mougenot (Compagnie Generale de Geophysique, France)

C. Bathymetric compilation of the area between Madeira and the Strait of Gibraltar compiled for GEBCO in 2000 by Peter Hunter, Southampton Oceanography Centre (SOC), United Kingdom

Sheet Limits: 31°N - 48°N; 18°W - 0°W (see below for detailed coverage)

Scale: Bay of Biscay (1:1.2 million); IBCEA Sheet 1.01 (1:1 million); Madeira/Strait of Gibraltar (1:500,000).

Horizontal datum: WGS-84

Contour Units: Bathymetric depth in corrected metres

Contours present: Bay of Biscay and IBCEA Sheet 1.01 contain contours at 200m intervals - also included in the digital data, but not on the published charts, are contours at 500m and at 1000m intervals thereafter. IBCEA Sheet 1.01 also includes contours at 50m, 100m and 150m. Madeira/Strait of Gibraltar contains contours at 20m, 50m, 100m and at 100m intervals thereafter. Additional intermediate contours may be found in abyssal areas.

Coastline Source: NIMA World Vector Shoreline at a scale of 1:250,000

Geographic Coverage:

32°10'N - 42°N; 15°20'W - 5°15'W:
42N° - 47°N; 16W° - 0°W:
47°N - 48°N; 13°W - 11°30'W and 7°30'W - 1°W:
plus an irregular area within 31°N - 32°40'N; 18°W - 14°W.

Within the above area, IBCEA Sheet 1.01 was used in the area north of 36°N between 15°20'W and 7°20'W; and south of 44°N between 12°W and 7°20'W but south of 43°N between 15°20'W and 12°W.

Digitization: Contours and tracklines for Areas A and C were digitised by BODC while contours for Area B were digitised by Instituto Hidrografico, Lisbon.

Published Charts: Sibuet, J-C., Monti, S. and Pautot, G. (1994). New bathymetric map of the Bay of Biscay. C. R. Acad. Sci. Paris, t.318, série II, p.615-625 including map published at a scale of 1:2.4 million. (Chart Limits: 43°N - 49°N; 18°W - 1°W).

Instituto Hidrografico (2002). Sheet 1.01 of the International Bathymetric Chart of the Central Eastern Atlantic (IBCEA) published by the Instituto Hidrografico, Lisbon, Portugal on behalf of the IOC and the IHO. Published at a scale of 1:1 million (Chart Limits: 36°N - 44°N; 15°20'W - 7°20'W).

PREPARATION OF GEBCO SHEET G.04

For the Bay of Biscay (Area A), Jean-Claude Sibuet provided BODC with the 1:1.2 million scale base chart version of the published chart, together with a corresponding chart (at the same scale) showing the multibeam coverage used in its compilation in the form of centre beam tracklines. The contours and tracklines were digitised from this material at BODC. Trackline information for the conventional soundings was taken from the NGDC GEODAS database although it should be noted that they do not fully represent all the conventional soundings used in the compilation. The 500m interval contours (i.e. at 500m, 1500m and at 1000m intervals thereafter) were interpolated from the 200m contours by Peter Hunter (SOC) and these were digitised at BODC.

Prior to its publication, the contours for IBCEA Sheet 1.01 were compiled at a scale of 1:250,000 in the form of a digital database at the Instituto Hidrografico, Lisbon and a DXF formatted copy of these data were submitted to BODC for incorporating into GEBCO. As with the Bay of Biscay chart, the 500m interval contours were interpolated from the 200m contours by Peter Hunter (SOC) and these were digitised at BODC. Trackline control information for IBCEA Sheet 1.01 is limited to a simple source diagram showing the origin of material used in the compilation of the contours in the various areas of the chart - unfortunately, it does not detail the data coverage available in these areas. The source diagram was digitised at BODC, together with the references.

The bathymetry for the Madeira/Strait of Gibraltar region (Area C) was compiled by Peter Hunter at SOC in a series of chartlets at a range of scales from 1:250,000 to 1:500,000. In general, the contouring was carried out at intervals of 100m although intervals of 20m or 50m were often used to better describe abyssal plain regions. Copies of the hand drawn contours were submitted to BODC for digitization and final edge-matching. The tracklines were submitted to BODC in digital form from a database maintained at SOC.

The merging and edge-matching of the contours from the three areas to form GEBCO sheet G.04 was carried out at BODC as was the edge-matching with the surrounding areas of the GEBCO Digital Atlas.

DATA SOURCES USED FOR GEBCO SHEET G.04 (AREA A: Bay of Biscay)

Extensive multibeam data collected by the IFREMER Centre de Brest including:

Seabeam data collected from RV Jean-Charcot from 1977 to 1983, as compiled in Lallemand et al. (1985), and on the Norestlante 3 cruise of 1989

EM12 data acquired on RV Atalante during the 1992 Brest-Dakar transit (Sibuet et al., 1993), the 1991 Sedimanche cruise (Bourillet et al., 1994) and the 1992 Zeegasc cruise (Pautot et al., 1995)

Conventional sounding data were acquired primarily from:

Service Hydrographique et Oceanographique de la Marine (SHOM), France, GEBCO Plotting Sheets: 42 and 43, up to 1989.

Vening Meinesz Laboratorium, Kroonvlag Project soundings compilations at 1:1,000,000 scale. University of Utrecht, The Netherlands.

The following were also consulted:

Lallemand, S., Maze, J.-P., Monti, S. and Sibuet, J.-C. (1985). Presentation d'une carte bathymetrique de l'Atlantique nord-est. C.R. Acad. Sc. Paris, Serie II, 300(4), 145-149. Bathymetric map (scale 1:2.4 million) published by IFREMER, France.

Laughton, A.S., Roberts, D.G. and Graves, R. (1975). Bathymetry of the northeast Atlantic : Mid-Atlantic Ridge to southwest Europe. Deep-Sea Research, 22, 791-810 and Admiralty chart C6568 (scale 1:2.4 million).

DATA SOURCES USED FOR GEBCO SHEET G.04 (AREA B: IBCEA Sheet 1.01)

IBCEA Sheet 1.01 includes a data source diagram where the data source(s) for each area are numerically referenced as follows:

1. Vanney, J.R., Rothwell, R.G. et al. (Groupe Transmarge) (1984). Leve bathymetrique a l'aide du sondeur multifasceaux SEABEAM du versant septentrional du Banc de Galice (marge continentale ouest iberique). Comptes Rendus, Academie des Sciences, Paris, Serie II, 299(3), 115-120.

2. Rojouan, F. (1985). Thesis - Universite de Paris-Sorbonne, France

3. Multibeam contours of Galicia Bank, Tore Seamount, Gorringe Bank and Setbal Canyon. IFREMER, France.

4. Mougenot, D., Kidd, R.B., et al., (1984). Geological interpretation of combined SEABEAM, GLORIA and seismic data from Porto and Vigo Seamounts, Iberian continental margin. Marine Geophysical Researches, 6, 329-363.

5. Vanney, J-R. and Mougenot, D. (1981). La plate-forme continentale du Portugal et les provinces adjacentes: analyse geomorphologique. Memorias dos Servicos Geologicos de Portugal, No. 28, 86 pp. and 41 figs.

   Lusitaine cruises 71,73,74,75; Hesperides cruises 76,78

6. Regnauld, H. (1987). Geormorphologie de la pente continentale du Portugal. Publiations du Department de Geographie de l'Universite de Paris-Sorbonne, No. 15, 141pp.

   Mougenot, D. (1989). Geologia da margem Portuguesa. Instituto Hidrografico, Lisboa, Documentos Tecnicos No. 32, 259pp.

7. Vanney, J-R. and Mougenot, D. (1990). A gouf-type Canyon, the Canhao da Nazare (Portugal). Oceanologica Acta, 13(1), 1-14 and bathymetric chart at scale 1:150,000.

8. H.M.S. Vidal (1959). Unpublished survey. (UK Hydrographic Office).

9. Soundings sheets maintained by IHPT, Instituto Hidrografico, Portugal.

10. Laughton, A.S., Roberts, D.G. and Graves, R. (1975). Bathymetry of the northeast Atlantic : Mid-Atlantic Ridge to southwest Europe. Deep-Sea Research, 22, 791-810 and Admiralty chart C6568 (scale 1:2.4 million).

    Lallemand, S., Maze, J.-P., Monti, S. and Sibuet, J.-C. (1985). Presentation d'une carte bathymetrique de l'Atlantique nord-est. C.R. Acad. Sc. Paris, Serie II, 300(4), 145-149. Bathymetric map (scale 1:2.4 million) published by IFREMER, France.

    Above two charts revised with data from Service Hydrographique et Oceanographique de la Marine (SHOM), France, GEBCO Plotting Sheets: 43 and 60.

DATA SOURCES USED FOR GEBCO SHEET G.04 (AREA C: Madeira - Strait of Gibraltar)

Contours were based on collected oceanic soundings from the following sources:

a) GEBCO Plotting Sheets of Collected Oceanic Soundings, up to 1983. Scale 1:1,000,000. Service Hydrographique et Oceanographique de la Marine (SHOM), Brest, France.

b) GEODAS Marine Trackline Geophysical Dataset, up to 1998. National Geophysical Data Center, NOAA, Boulder, U.S.A.

c) Southampton Oceanography Centre (formerly Institute of Oceanographic Sciences), up to 1998. Natural Environment Research Council, U.K.

The following was widely consulted:

Hunter, P.M., Searle, R.C. and Laughton, A.S. (1983). Bathymetry of the Northeast Atlantic, Sheet 5: Continental Margin Off West Africa, Scale 1:2,400,000. Admiralty Chart C6570, Hydrographer of the Navy, Taunton, U.K.

Detailed surveys were included from the following sources:

Ampere Seamount, scales 1:50,000 and 1:100,000. Unpublished chart. Alfred Wegener Institute, Bremerhaven, Germany.

Auzende, J.M., Monti, S. and Ruellan, E. (1983). Carte Bathymetrique de L'Escarpment de El Jadida (Mazagan), scale 1:100,000. Centre National pour l'Exploitation des Oceans (CNEXO), Brest, France.

R.R.S. 'Discovery' Cruise 144, 1984. Unpublished GLORIA sidescan sonar images. Institute of Oceanographic Sciences, Wormley, U.K.

R.R.S. 'Discovery' Cruise 161, 1986. Unpublished GLORIA sidescan sonar images. Institute of Oceanographic Sciences, Wormley, U.K.

Vanney, J-R and Mougenot, D. (1981). La Plate-forme Continentale du Portugal et les Provinces Ajacentes: Analyses Geomorphologique. Memorias dos Servicos Geologicos de Portugal, Lisboa, No. 28, 86 pp and 41 figures.

Western Approaches to the Strait of Gibraltar, Submarine Topography, Scale 1:1,000,000, 1969. Admiralty chart C6101. Hydrographer of the Navy, Taunton, U.K.

ANNEX K.5: GEBCO Sheet G.05
(Mid Atlantic Ridge to NW Africa)

Author:	Compiled for GEBCO (2002) by Peter M. Hunter, Southampton Oceanography Centre, United Kingdom.
Note:	East of the 4600m contour off the coast of NW Africa, the bathymetry is taken from sheet 1.06 of the International Bathymetric Chart of the Central Eastern Atlantic (IBCEA) compiled by the Service Hydrographique et Oceanographique de la Marine (SHOM), France.
Sheet Limits:	18°N –35°N; 47°W - 14°W (see below for detailed coverage)
Scale:	Contours compiled and digitised at a range of scales from 1:250,000 to 1:1,250,000 million.
Horizontal Datum:	WGS-84
Contour Units:	Bathymetric depth in corrected metres.
Contours present:	The area of the sheet from the 4600m contour westwards to 30°W is contoured at 100m intervals. West of about 30°W, the bathymetry is contoured at 500m intervals. The area of IBCEA sheet 1.06 has contours at 50m, 100m, 200m and at 200m intervals thereafter, including intermediate 500m interval contours.
Coastline Source:	NIMA World Vector Shoreline at a scale of 1:250,000

Geographic Coverage:

18°N – 20°N; 40°W - 30°W
19°14'N – 20°N; 24°58'W - 14°W
20°N – 25°53'N; 47°W - 14°W
25°53'N – 30°N; 47°W - 20°W
30°N – 32°N; 47°W - 39°30'W
30°N – 31°11'N; 31°13'W - 20°W
31°11'N – 32°N; 30°W - 20°W
32°N – 34°30'N; 30°W - 21°W
34°30'N –35°N; 30°W - 23°33'W

Digitization:	Contours digitised by BODC with tracklines submitted by SOC in digital form. IBCEA sheet 1.06 contours digitised by SHOM with trackline control provided in the form of sounding points.
Reference:	IBCEA Sheet 1.06 was published by SHOM on behalf of the IOC in October 2000. Scale of 1:1 million, with contours at 50m, 100m, 200m and at 200m intervals thereafter. Sheet limits: 19°14'N – 25°53'N; 24°58'W - 14°28'W

PREPARATION OF GEBCO SHEET G.05

The bathymetry was compiled by Peter Hunter at SOC in a series of charts at a range of scales from 1:750,000 to 1:1,250,000. In general, the contouring was carried out at intervals of 100m, although west of about 30°W the interval was increased to 500m. Copies of the hand drawn contours were submitted to BODC for digitization and final edge-matching. The tracklines were submitted to BODC in digital form from a database maintained at SOC. Tracklines for data assimilated from hard-copy collected soundings sheets were taken from the tracklines already digitised for GEBCO Sheet 5.08. Contouring was carried out as a geomorphological interpretation of the available data and reference was made to the satellite altimetry predictions of Smith and Sandwell (1997) and existing charts. The bathymetry for IBCEA Sheet 1.06 was compiled at a scale of 1:250,000 and submitted by SHOM to BODC in digital form - although the published chart was based on 200m interval contours, additional contours at 500m intervals were provided by SHOM so as to accord with GEBCO standards.

Edgematching of the contours to surrounding areas in the GEBCO Digital Atlas was carried out at BODC.

Contours were based on collected oceanic soundings from the following sources:

a) GEBCO Plotting Sheets of Collected Oceanic Soundings, up to 1983. Scale 1:1,000,000. Service Hydrographique et Oceanographique de la Marine (SHOM), Brest, France.

b) GEODAS Marine Trackline Geophysical Dataset, up to 1998. National Geophysical Data Center, NOAA, Boulder, U.S.A.

c) Southampton Oceanography Centre (formerly Institute of Oceanographic Sciences), up to 1998. Natural Environment Research Council, U.K.

d) Vening Meinesz Laboratorium, Kroonvlag Project soundings compilations at 1:1,000,000 scale. University of Utrecht, The Netherlands.

   (Published as: Collette, B.J. and Roest, W.R. (1992). Further investigations of the North Atlantic between 10° and 40°N and an analysis of spreading from 111 Ma ago to present. Proceedings of the Koninklijk Nederlandse Akademie van Wetenschappen, 95(2), 159-206 & 5 charts.)

The following were widely consulted:

Hunter, P.M., Searle, R.C. and Laughton, A.S. (1983). Bathymetry of the Northeast Atlantic, Sheet 5: Continental Margin Off West Africa, Scale 1:2,400,000. Admiralty Chart C6570, Hydrographer of the Navy, Taunton, U.K.

Hunter, P.M., Searle, R.C. and Laughton, A.S. (1986). Bathymetry of the Northeast Atlantic, Sheet 4: Mid-Atlantic Ridge to the Canary Basin, Scale 1:2,400,000. Unpublished chart. Institute of Oceanographic Sciences, Wormley, U.K.

Global 2 min grid of Measured and Estimated Seafloor Topography. Smith, W. H. F. and D. T. Sandwell (1997). Global Seafloor Topography from Satellite Altimetry and Ship Depth Soundings, Science, v. 277, p. 1956-1962

Detailed surveys were included from the following sources:

N.O. 'Jean Chartcot' Campagne Transwal, 1979. Unpublished multibeam contours. IFREMER, Brest, France.

Gridded Bathymetry on the Mid-Atlantic Ridge. RIDGE Multibeam Synthesis Project, L-DEO, Columbia University, U.S.A.

COMPILATION OF IBCEA SHEET 1.06

The compilation and digitization of the bathymetric contours for IBCEA Sheet 1.06 was carried out by SHOM. Available sounding data from collected soundings sheets and single and multibeam surveys were assembled into a digital database with all data corrected according to “Echo-Sounding Correction Tables” (publication NP 139, 2nd and 3rd editions, Hydrographic Office, United Kingdom). The data were plotted onto 1:250,000 sheets where they were manually contoured at intervals of both 200m and 500m. Geomorphological considerations were applied in the contouring and reference was made to satellite altimetry data, existing charts and available books, reports and archives. The contours were then digitised and submitted to BODC for use in GEBCO – the trackline control was submitted in digital form expressed as sounding points for both single and multibeam data.

IBCEA Sheet 1.06 - Sources of soundings:

Bundesamt fur Seeschiffahrt und Hydrographie, Hamburg, Rostock
Canadian Hydrographic Service, Ottawa
U.S. National Imagery and Mapping Agency (NIMA), Silver Spring, Maryland
Head Department of Navigation and Oceanography, St Petersburg
South African Naval Hydrographic Office, Cape Town
Dienst der Hydrografie Koninklijke Marine, Gravenhage
UK Hydrographic Service, Taunton
International Hydrographic Bureau, Monaco
Instituto Hidrografico, Lisboa
Instituto Hidrografico de la Marina, Cadiz
National Geophysical Data Center, Boulder, Colorado
National Ocean Service, Silver Spring, Maryland
Service Hydrographique et Oceanographique de la Marine, Paris.

IBCEA Sheet 1.06 - Sources of detailed bathymetric surveys:

Institut National des Sciences de l’Univers (INSU)
Institut Francais de Recherche Scientifique pour le developpement en cooperation (ORSTOM): JEAN CHARCOT (1971)
Institut Francais de Recherche de l’Exploitation de la Mer (IFREMER): JEAN CHARCOT (1988), SUROIT (1983), ATALANTE (1992 to 1995)
Institute of Oceanographic Sciences (IOS): DISCOVERY (1983)
Lamont-Doherty Geological Observatory: VEMA (1961 to 1973), CONRAD (1973)
Scripps Institution of Oceanography: GLOMAR CHALLENGER (1975)
Texas A & M University: JOIDES RESOLUTION (1986)
US Geological Survey (1971)
Woods Hole Oceanographic Institute: ATLANTIS II (1973)

IBCEA Sheet 1.06 - Charts consulted:

Gravimetrie – Anomalies a l'air libre (pour IBCEA), d'apres le modele Smith, W.H.F. & Sandwell, D.T., J.G.R. 99, 1997, SHOM, Paris, France, 1997,1998.

Topographie (pour IBCEA) predite a partir de donnees altrimetriques et bathymetriques. (Modele Smith, W.H.F. & Sandwell, D.T., J.G.R., 99, 1994). SHOM, Paris, France, 1997.

Hunter, P.M., Searle, R.C. and Laughton, A.S. (1983). Bathymetry of the Northeast Atlantic, Sheet 5: Continental Margin Off West Africa, Scale 1:2,400,000. Admiralty Chart C6570, Hydrographer of the Navy, Taunton, U.K.

ANNEX K.6: GEBCO Sheet G.06

(Central Eastern Atlantic)

INTERNATIONAL BATHYMETRIC CHART OF THE CENTRAL EASTERN ATLANTIC (IBCEA)

(IBCEA Sheets 1.08, 1.09, 1.10, 1.11 and 1.12 published by the Service Hydrographique et Oceanographique de la Marine (SHOM), Paris over the period 1999 to 2001)

Author:	Bathymetry compiled by SHOM under the guidance of the IOC Editorial Board for IBCEA
Editorial Board:	Andre Roubertou (Chairman, France); Isabelle Niang-diop (Vice-Chairman, Senegal); Gilles Bessaro, Michel Le Gouic (France); Boubacar Diallo (Guinee); Michel Huet (IHB); Laurence Awosika (Nigeria); Jose Manuel Fialho Lourenco (Portugal); Vladim Sobolev (Russia); Director, Instituto Hidrografico de la Marina (Spain); Mensah Koffi Nutsudza (Togo); E. John W. Jones (U.K.); Troy Holcombe (U.S.A.); in collaboration with Olivier Vicaire (doctor of geophysics) (France).
Sheet Limits:	Composite from IBCEA 1.08: 5°11'N –12°18'N; 21°47'W - 11°17'W (May 1999) IBCEA 1.09: 0°31'S – 6°40'N; 20°30'W – 10°00'W (October 2000) IBCEA 1.10: 0°31'S – 6°40'N; 10°00'W – 0°30'E (October 2000) IBCEA 1.11: 0°31'S – 6°40'N; 0°30'E – 11°00'E (March 2001) IBCEA 1.12: 7°42'S - 0°31'S; 3°10'E - 13°40'E (March 2001) (publication dates of printed charts)
Scale:	Contours compiled and digitised at a scale of 1:250,000. Printed charts published on Mercator projection at 1:1 million at 20°N.
Horizontal Datum:	WGS84
Contour Units:	Bathymetric depth in corrected metres
Contours present:	50m, 100m, 200m and at 200m intervals thereafter down to a maximum contour depth of 7800m. Also included in the digital data, but not on the printed sheets, are contours at 500m and at 1000m intervals thereafter.
Coastline Source:	NIMA World Vector Shoreline at a scale of 1:250,000
Digitisation:	Contours digitised by SHOM with trackline control data provided in the form of sounding points.
Note:	Due to the absence of data from bathymetric surveys, some seamounts belonging to Mungo Park Seamounts (on IBCEA 1.11) and the Pierre Brazza and Paul du Chaillu Seamounts (on IBCEA 1.12), which seem characteristic, are included on the sheets based satellite altimetry data.

PREPARATION OF GEBCO SHEET G.06

The compilation and digitization of the bathymetric contours was carried out by SHOM. Available sounding data from collected soundings sheets and single and multibeam surveys were assembled into a digital database with all data corrected according to “Echo-Sounding Correction Tables” (publication NP 139, 2nd and 3rd editions, Hydrographic Office, United Kingdom). The data were plotted onto 1:250,000 sheets where they were manually contoured at intervals of both 200m and 500m. Geomorphological considerations were applied in the contouring and reference was made to satellite altimetry data, existing charts and available books, reports and archives. The contours were then digitised and submitted to BODC to form GEBCO Sheet G.06 – the trackline control was submitted in digital form expressed as sounding points for both single and multibeam data. Edgematching of the contours to surrounding areas in the GEBCO Digital Atlas was carried out at BODC.

SOURCES OF BATHYMETRIC SOUNDINGS ALONG TRACKLINES:

Bundesamt fuer Seeschiffahrt und Hydrographie, Hamburg, Rostock
Canadian Hydrographic Service, Ottawa
U.S. National Imagery and Mapping Agency (NIMA), Silver Spring, Maryland
Head Department of Navigation and Oceanography, St Petersburg
South African Naval Hydrographic Office, Cape Town
Dienst der Hydrografie Koninklijke Marine, Gravenhage
UK Hydrographic Service, Taunton
International Hydrographic Bureau, Monaco
Instituto Hidrografico, Lisboa
Instituto Hidrografico de la Marina, Cadiz
National Geophysical Data Center, Boulder, Colorado
National Ocean Service, Silver Spring, Maryland
Service Hydrographique et Oceanographique de la Marine, Paris.

SOURCES OF DETAILED BATHYMETRIC SURVEYS:

Bureau Gravimetrique International
Institut National des Sciences de l’Univers (INSU)
Institut Francais de Recherche Scientifique pour le developpement en cooperation (ORSTOM): JEAN CHARCOT (1971, 1979)
Institut Francais de Recherche de l’Exploitation de la Mer (IFREMER): JEAN CHARCOT (1988,1990), SUROIT (1983), ATALANTE (1992 to 1995)
Institute of Oceanographic Sciences (IOS): DISCOVERY (1983)
Lamont-Doherty Geological Observatory: VEMA (1961 to 1973), CONRAD (1973)
Scripps Institution of Oceanography: GLOMAR CHALLENGER (1975)
Texas A & M University: JOIDES RESOLUTION (1986)
US Geological Survey (1971)
Woods Hole Oceanographic Institute: CHAIN (1961 to 1973), ATLANTIS II (1973)
SHOM: Mission Hydrographique de la cote Ouest d’Afrique (MHCOA), LEON COURSIN (1958 to 1960), chasseur P699 (1960) et BEAUTEMPS BEAUPRE.

CHARTS CONSULTED:

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Topographie (pour IBCEA) predite a partir de donnees altrimetriques et bathymetriques. (Modele Smith, W.H.F. & Sandwell, D.T., J. G R., 99, 1994). SHOM – PARIS – FRANCE, 1997.

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ANNEX K.7: GEBCO Sheet G.07
(Weddell Sea and the Bransfield Strait)

BATHYMETRIC CHART OF THE WEDDELL SEA (compiled 1997, extended 2001)

(Update history: a subset of this sheet was released as GEBCO sheet 97.2 in the 1997 release of the GEBCO Digital Atlas covering the area of the Weddell Sea south of 65°S and west of 0°W. Subsequently updated and extended in the region 60°S to 65°S; 75°W to 15°W in the northern Weddell Sea and around the Antarctic Peninsula, the Bransfield Strait and westwards. Also updated and extended in the region 66°S to 72°S; 2°W to 2°E)

Chief Editors:	Hans Werner Schenke (Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany) and Gleb B. Udintsev (Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow)
Sheet Limits:	60°S to 79°S; 75°W to 2°E (see below for detailed coverage)
Scale:	Contours compiled and digitised on Mercator sheets at a variety of scales between 1:250,000 and 1:1 million
Horizontal Datum:	WGS-84
Contour Units:	bathymetric depth in uncorrected metres (assuming a sound velocity in seawater of 1500m/s - see note below)
Contours present:	100m intervals down to 7200m
Coastline Source:	SCAR Coastline of Antarctica, version 3.0 (full resolution version at scale of 1:1 million and better).
Digitised by:	Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

Geographic Coverage:

60°S to 66°S; 75°W to 15°W
65°S to 66°S; 15°W to 2°W
66°S to 79°S; 75°W to 2°E

Published Charts: Printed charts published by the Alfred Wegener Institute as a series of nine sheets (533-535, 551-553, 566-568) as part of the 1:1 million scale "AWI Bathymetric Chart of the Weddell Sea, Antarctica". Sheets 533-535 published jointly with Vernadsky Institute of Geochemistry and Analytical Chemistry. Coverage as follows:

60°-66°S: 75°-55°W (533); 55°-35°W (534); 35°-15°W (535)
66°-72°S: 66°-50°W (551); 50°-25°W (552); 25°-0°W (553)
72°-78°S: 75°-50°W (566); 50°-25°W (567); 25°-0°W (568)

Note on contour units: Prior to contouring for use in GEBCO charts, echo-soundings are normally corrected for regional variations in the velocity of sound in seawater by the use of Carter's Tables (NP132, "Echo-Sounding Correction Tables", 3rd Edition, D.J.T. Carter,

Hydrographic Department, Taunton, 1980). However, for GEBCO Sheet G.07, such corrections were not made as there is considerable uncertainty on the accuracy of Carter's Tables in the area of the Weddell Sea and the sound velocity was assumed to be 1500m/s throughout the water column. By way of comparison it may be noted that, for the Weddell Sea area, the corrections from Carter's Tables are as follows:

Contour depth (m)	200	500	1000	1500	2000	2500	3000
Correction (m)	-8	-18	-29	-39	-47	-53	-55

Contour depth (m)	3500	4000	4500	5000	5500	6000
Correction (m)	-54	-51	-45	-36	-24	-8

PREPARATION OF GEBCO SHEET G.07

This data set was compiled in two parts; Area A (65°-79°S: 66°-0°W) which was submitted by AWI to BODC in 1997 and Area B (60°-66°S: 75°-15°W) which was submitted by AWI in 2001. Area B updates the bathymetry of Area A in the overlapping area between 65°-66°S. In 2001, AWI also provided BODC with updated bathymetry for the area from 2°W to 2°E.

PREPARATION OF AREA A

Authors: Hans Werner Schenke, Heinrich Hinze, Fred Niederjasper, Tilo Schone, Bernd Hoppmann, and Semme Dijkstra, Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven, Germany

Until the AWI started its scientific activities in the Weddell Sea in 1983 using the ice breaking research vessel RV Polarstern, few soundings were available for compiling a bathymetric chart of the area. Since then more than 40 expeditions have taken place in the region, including more than 20 cruises of RV Polarstern with continuous multi-beam echo-sounding using either Seabeam or Hydrosweep systems.

Area A is based on the Polarstern data and on additional echo-sounding data supplied by several national Hydrographic Offices and research institutions. Due to the hostile nature and high latitude of the area, the data coverage is very irregular and the quality of the data is highly variable with navigation uncertainties and recording errors. Digital Terrain Modelling (DTM) techniques were used to assist in the assimilation of the soundings. Prior to final acceptance, each track of data was verified by checking for crossover errors and for reasonable navigation (e.g. checking ship speed) and by comparing the data with the developing DTM, with neighbouring soundings and with the morphological fabric of the area. Obviously erroneous data were corrected if possible (e.g. by adjusting the navigation) or eliminated. During the verification, the data were assigned a quality factor for use in weighting the contribution of the data in the construction of the DTM. Within the DTM the grid size varied from 0.5 to 2.5 n.miles depending on the data density and the complexity of the underlying topography.

All verified depth data were included in the final calculation of the DTM which was then contoured automatically at 50m intervals and plotted out. The plots were evaluated against other available geophysical and geological data such as satellite altimetry, gravity, magnetic, tectonic and seismic data. Various fabrics resulting from tectonic effects, glacial and oceanographic erosion are observed in the Weddell Sea and the contours were adjusted to be consistent with the properties of such fabrics. Correlations found in well surveyed areas were used to predict the bathymetry in ice covered areas or to supplement the bathymetry in sparsely surveyed areas. If structures in the bathymetry did not appear plausible, the reliability of the depth data was re-evaluated. Reported but unconfirmed or suspect depths were omitted if they conflicted with the morphological evidence of other sources.

By comparing the depth data with the other data it was possible to verify the plausibility of the sea floor structures together with their extension and orientation. The contours were manually adjusted as necessary during this interpretive phase of the compilation, particularly in the sparsely sounded areas. It should be noted that, due to ice cover, there is a paucity of soundings in the western, central and southern parts of the Weddell Sea and the contours in these regions are somewhat speculative.

Drafting and final contouring was carried out at scales of 1:1 million or better; the exact scale being dependent on the density of data and the roughness of the topography. The resulting contours were smoothed by hand and manually digitised. After a careful edgematching of the various sheets, the digital data set was then submitted to BODC for incorporating into the GEBCO Digital Atlas. The digital trackline control information was generated automatically from the soundings database maintained within the AWI's mapping system.

PREPARATION OF AREA B

Chief Editor: H.-W. Schenke, G. B. Udintsev, D. E. Teterin
Scientific Compilation: G. B. Udintsev, D. E. Teterin, G. V. Agapova, S.Barthel

The sheet was extended into Area B in the framework of a joint German-Russian collaboration between AWI and the V.I. Vernadsky Institute for Geochemistry and Analytical Chemistry, Moscow. In addition to the multibeam data collected by RV Polarstern, the compilation benefited from extensive multibeam surveying by RV Akademic Boris Petrov. Bathymetric contouring was based on a newly established data base comprising all existing single and multi beam data. In data sparse areas, the method of morphological interpolation was utilized and additional information from satellite radar altimetry gravity anomalies was included. The initial computer contouring was made from a DTM at scales of 1:400,000 and 1:800,000 in 100 m contour line intervals. This was followed by a manual interpretative editing of the seafloor topography, utilizing the morphological regularities and radar altimetry information. The final contours were digitised by scanning and, after vectorising, included in a Geographic Information System (GIS) for the cartographic visualization and charting. The contour lines were generalized, smoothed and edited for the final scale of 1:1 million. The digital data set was then submitted to BODC for incorporating into the GEBCO Digital Atlas together with digital trackline control information generated automatically from the soundings database.

DATA SOURCES USED FOR GEBCO SHEET G.07 (Area A)

Although multi-beam data from RV Polarstern provided the singlemost extensive source of data, analogue and digital sounding data were also supplied by many other organisations for use in compiling Area A. In particular, the following Hydrographic Offices contributed data:

Servicio de Hidrografia Naval, Buenos Aires, Argentina
Diretoria de Hidrografia e Navegacao, Niteroi, Brazil
Hydrographic Department, Tokyo, Japan
Statens Kartverk, Stavanger, Norway
Hydrographic Office, Cape Town, South Africa
Hydrographic Office, Taunton, UK
Defense Mapping Agency, Washington, USA
Head Department of Navigation & Oceanography, St. Petersburg, Russia

The following scientific institutions or individuals supplied data:

British Antarctic Survey, Cambridge, UK (C. Doake, B. Harrods)
Bureau Gravimetrique International, Toulouse, France
Institute of Geophysics, University of Texas, USA (B.J. Sloan, L.A. Lawver)
Japan Oceanographic Data Centre, Tokyo
Lamont Doherty Earth Observatory, New York, USA (A.L. Gordon, B. Huber)
National Geophysical Data Center, Boulder, USA
National Institute of Polar Research, Japan
Norwegian Polar Research Institute (A. Solheim)
Sevmorgeologia, Russia (V. Krukov, V. Masolov, V. Pozdeev)

Digital data sets used as an aid to interpreting the bathymetry included those referenced in:

Heidrich, B., Sievers, J., Schenke, H.W. and Thiel, M. (1992), Digitale topographische Datenbank Antarktis. Nachr. a.d. Karten- u. Verm. wesen I/107, p.127-140.

Sandwell, D.T. and Smith, W.H.F. (1992), Global Marine Gravity from ERS-1, GEOSAT and SEASAT reveals New Tectonic Fabric. EOS trans. AGU 73, p.133, Fall 1992 AGU Meeting Supplement.

Schone, T. (1997), Ein Beitrag zum Schwerefeld im Bereich des Weddellmeeres, Antarktika: Zur Nutzung von Altimetermessungen des GEOSAT und ERS-1, Ber.Polarf.220.

Additional background data were extracted from publications, especially:

Ghidella, M.E. and LaBreque, J.L. (1990), Consideraciones sobre la morfologia del Mar de Weddell oeste basados en datos aerogeofisicos. In CLAF 1991, p34-44.

Hoppe, H. and Thyssen, F. (1988), Ice thickness and bedrock elevation in western Neuschwabenland and Berker Island. Annals of Glaciology 11, p.42ff.

Huybrechts, P. (1992), The Antarctic ice sheet and environmental change: a three-dimensional modelling study. Ber.Polarf. 99

Japanese Antarctic Research Expeditions (1980-1987), Data Reports 76 to 149.

Kobarg, W. (1988), The tide-dependent dynamics of the Ekstroem Ice Shelf, Antarctica. Ber. Pol. forschung 50

Pozdeyev, V.S. and Kurinin, R.G. (1987), New data on the morphology of the ice cover and relief of the subglacial bed and seabed bottom in the southern part of the Weddell Sea basin. In. Antarktika. Doklady Komissii 26, p.66-71, English translation 1987.

Robin, G. de Q. (1958), Seismic shooting and related investigations. Norwegian-British-Swedish Antarctic Expedition, 1949-52. Scientific Results, Vol.V, Glaciology III. NPI, Oslo.

Vaughan, D.G., Sievers, J., Doake, C.S.M., Hinze, H., Mantripp, D.R., Pozdeev, V.S., Sandhager, H., Schenke, H.W., Solheim, A. and Thyssen, F. (1994), Subglacial and Seabed Topography, Ice Thickness and Water Column Thickness in the Vicinity of Filchner-Ronne-Schelfeis. Polarforschung 64 (2), p.75-88.

DATA SOURCES USED FOR GEBCO SHEET G.07 (Area B)

Source Data

The singlemost extensive source of data for compiling Area B bathymetry was provided by the cruises of RV Akademic Boris Petrov and RV Polarstern:

- Alfred Wegener Institute for Polar and Marine Research, Germany: RV "Polarstern" Antarctic expeditions (since 1983): Multibeam data from SeaBeam and Hydrosweep system, single beam data from navigation echo sounder, narrow beam echo sounder and Parasound sediment echo sounder. Multibeam surveys by Hans Werner Schenke, Fred Niederjasper and Tilo Schone.

- Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, Russia: RV “Akademik Boris Petrov” Antarctic expeditions GAP 95 and GAP 98: Multibeam data from Hollming Ekhos II system and from narrow beam echo sounder. Multibeam surveys by Gleb Udintsev, Hans Werner Schenke, and Tilo Schone.

Supporting data and information, including analogue and digital sounding data, were provided by many other organizations. In particular, use was made of the following:

Scientific Databases:

- IHO Data Centre for Digital Bathymetry, Boulder, Colorado; U.S. National Geophysical Data Centre, GEODAS searches on bathymetry: November 1992, April 1993, May 1999, October 1999

- Antarctic Digital Database, Version 3.0, 2000, ADD Consortium, Scientific Committee on Antarctic Research, Scott Polar Research Institute, Cambridge, UK.

- Marks K.M., McAdoo D.C., 1992, Gravity Atlas of the Southern Ocean. National Geophysical Data-Centre-A for Marine Geology and Geophysics. Reports. MGG-7, Wash. (D.C.), U.S. Dept. Commerce.

- Sandwell D.T., Smith W.H.F., 1997, Marine Gravity Anomaly from Geosat and ERS-1 Satellite Altimetry, J. Geophys. Res., v. 102, p. 10,039-10,054.

- Smith, Walter H. F.; Sandwell, David T., 1997, Global sea floor topography from satellite altimetry and ship depth soundings, Science, v. 227, 5334, p. 1956-1962.

- GEBCO Sheets 5.16 and 5.18, bathymetric contours, track lines and bedrock contours

National Hydrographic Offices:

- Nautical Charts (various scales): Argentina, Russian Federation, United Kingdom

- GEBCO Ocean Plotting Sheets (OPS) 1:1,000,000: Argentina, Republic of South Africa, United Kingdom; 1:5,000,000: Russian Federation

- Digital Data: Russian Federation, United Kingdom, United States of America

Scientific Publications:

- Gracia E., Canals M., LiFarran M., Sorridas J., Pallas R., 1997, Central and Eastern Bransfield Basins (Antarctica) from high-resolution swath-bathymetry data. Antarctic Science, 9 (2), p. 168-180

- Lawver L.A., Sloan B.J., Barker D.H.N., Ghidella M., von Herzen R.P., Keller R. A., Klinkhammer G.P, 1996, Distributed, Active Extension in Bransfield Basin, Antarctic Peninsula: Evidence from Multibeam Bathymetry. GSA Today, v. 6, No. 11, p. 1-7, 16-17

- Schenke, H.-W., Dijkstra, S., Niederjasper, F., Hinze, H., Hoppmann, B., Schone, T., 1998, The New Bathymetric Charts of the Weddell Sea: AWI BCWS, In: Ocean, Ice, and Atmosphere: Interactions at the Antarctic Continental Margin, Stanley S. Jacobs and Raymond F. Weiss (eds.) - Washington, DC: American Geophysical Union, 1998 (Antarctic Research Series; Vol. 75) 371-380.

- Tectonic Map of the Scotia Arc, 1985, 1:3,000,000; BAS (Misc.) 3, Cambridge, Survey.

- Vegas R., Acosta J., Uchip E., 1995, Continental-Oceanic Crustal Transition in the Bransfield Trough and the South Scotia Ridge (Antarctica); preliminary results, in: E. Banda et al. (eds.) Rifted Ocean-Continent Boundaries, p. 265-289, Kluwer Academic Publisher.

ANNEX K.8: GEBCO Sheet G.08
(Greater Indian Ocean)

BATHYMETRY OF THE GREATER INDIAN OCEAN (compiled September 2002)

(Note: a subset of this sheet was released as GEBCO sheet 97.1 in the 1997 release of the GEBCO Digital Atlas covering the area of the Indian Ocean south of 31°S and extending from 10°W in the South Atlantic to 140°E south of Australia. This area has been further updated and the sheet now extends to cover the whole of the Indian Ocean from Asia down to Antarctica, extending eastwards to 170°E in the south-west Pacific and westwards to 12°W in the south-east Atlantic. The area covered is about a quarter of the world's oceans)

Author:	Dr. Robert L. Fisher, Scripps Institution of Oceanography, La Jolla, California, USA
Digitised by:	Pauline Weatherall, British Oceanographic Data Centre
Sheet Limits:	31°N to 72°S; 12°W to 170°E (see below for detailed coverage)
Scale:	Contours compiled and digitised on Mercator sheets at a scale of 4 inches per degree longitude (i.e. approximately 1:1 million)
Horizontal Datum:	WGS-84
Contour Units:	Bathymetric depth in corrected metres
Contours present:	standard GEBCO depths i.e. 200m, 500m and at 500m intervals thereafter down to 7000m. Locally the 100m contour is also present.
Coastline Source:	SCAR Coastline of Antarctica south of 60°S (Version 3.0; Full resolution version at a scale of 1:1 million or better). NIMA World Vector Shoreline north of 60°S. (Scale of 1:1 million.)

Geographic Coverage:

a) SE Atlantic from 24°S to 72°S; 12°W to 20°E with an extension to 20°W between 56°S to 60°S. South of 65°S and west of 2°E, the bathymetry is provided by GEBCO sheet G.07 and the two sheets are merged at this boundary.

b) Indian Ocean from 20°E to 147°E, from Asia down to Antarctica (including the Gulf of Aden). The north east boundary with the South China and Eastern Archipelagic Seas is along a line taken between 9°N,99°E; 0°N,105°E; 0°N,115°E; 4°N,115°E; 4°N,136°E; and then southwards to the coast of Australia.

c) SW Pacific from 24°S to 72°S; 147°E to 170°E but restricted in the northeast where it abuts, and is merged with, GEBCO sheet G.09 – in this region the eastern limit is as follows: 24°-31°S,158.6°E; 31°-47°S,157°E; 47°-54°S,165°E; 54°-57.5°S,163.5°E.

PREPARATION OF GEBCO SHEET G.08

The compilation and hand contouring of all echo-sounding data used in the construction of Sheet G.08 was carried out by Dr. Robert L. Fisher of the Scripps Institution of

Oceanography (SIO) as part of the International Indian Ocean Data Compilation Project (IODCP), a collaborative venture between scientists at SIO and L'Ecole et Observatoire de Physique du Globe, Strasbourg, France. The project's aim is to produce a detailed tectonic chart for the entire Indian Ocean and the contiguous Southern Ocean between 5°W to 166°E. It will include the compilation and interpretation of all available bathymetric, magnetic and satellite-derived gravity data from Africa-Asia-Australia south to Antarctica.

The basic "source document" used for the bathymetric contouring was the 1950-1995 compilation of echo-sounding data maintained by Dr. Fisher at SIO on a set of 240 or so hard copy oceanic scale (4 inches to 1 degree of longitude, Mercator projection) plotting sheets. These were augmented in very large degree by further soundings contributed by academic and government agency sources (as listed below). These sources contributed data either as hard copy plotting sheets (typically 1:1 million scale Mercator plots) or as digital files of cruise navigation and soundings accompanied by standard velocity correction notations. The digital files were plotted out for Dr. Fisher by Virginia Wells and Uta Albright at SIO's Geological Data Center. During the compilation, the soundings were compared and checked for recording errors and, for pre-satellite-navigated tracks, slight track adjustments were made as necessary to minimize crossover discrepancies. A compilation of tracklines, corrected for digitising errors and omitting segments without soundings, was compiled concurrently on a parallel set of hard copy plotting sheets at the same scale.

The sounding data were hand contoured by geological interpretation by Dr. Fisher sheet by sheet, employing multiple cruise sounding overlays as required for legibility and clarity. In contouring, the standard GEBCO contour levels were followed i.e. 500m intervals, plus the 200m contour and, occasionally, on wide shelves, the 100m contour. The contoured depths are in "corrected metres" using Carter's Tables (NP 139, "Echo-Sounding Correction Tables", 3rd Edition, D.J.T. Carter, Hydrographic Department, Taunton, 1980). None of the contouring was taken from existing nautical or scientific publications or manuscripts; rather, all was done by hand from 1987 to 2002 by Dr. Fisher from his collection of soundings sheets.

In constructing the contours, the echo-sounding based interpretation was compared with large-scale portrayals of satellite altimetry "topography". Such gravity-based portrayals were constructed from a data file available at SIO (Sandwell, D.T. and W.H.F. Smith, "Marine Gravity Anomalies from GEOSAT and ERS-1 Altimetry", (version 7.2, Aug. 1996), Journal of Geophysical Research, vol.102, p.10,039-10,054). These comparisons at large scale helped eliminate spurious structural trends or major misconnections in regions contoured from sparse shipboard coverage. However, depth contour levels are based entirely on sounding data; gravity indications affected only the general shape of features detectable from existing soundings.

The hand contoured sheets at a scale of 4 inches per degree longitude and their corresponding trackline plots were duplicated at SIO and sent to the British Oceanographic Data Centre (BODC) at the Proudman Oceanographic Laboratory, Birkenhead, UK - a total of some 250 pairs of sheets! The contours and tracklines were digitised by Pauline Weatherall at BODC employing raster scanning techniques and subsequent vectorisation and labelling using Laser-Scan's VTRAK system. Careful control was exercised in the geographic registration of the material which was checked at one degree intervals of both latitude and longitude across the full area of each sheet. Both contours and tracklines were digitised with a registration accuracy within the line thickness of the source material. For the area between 10°W and 20°E, the contours were hand digitised by Karen Walters and Jon Anderson at SIO and the files transmitted to BODC for quality control. Miss Weatherall was responsible for edgematching the digitised contours across sheet boundaries so as to provide a seamless data set. She was also responsible for incorporating a digital coastline into the data set using the Defense Mapping Agency's World Vector Shoreline (north of

60°S) and the Scientific Committee on Antarctic Research's coastline of Antarctica (south of 60°S). Careful checks were made to ensure that the bathymetric contours were consistent with the coastlines, particularly around islands.

The contouring and digitising work was undertaken over a period of more than 10 years – as new sounding data continued to be acquired over this period, the bathymetry was updated as and when appropriate. As a result of this, over 600 sections of update charts were delivered to BODC for digitising during the project, in addition to the 250 'first version' sheets. The work was completed in September 2002.

DATA SOURCES USED FOR GEBCO SHEET G.08

During the compilation of data for GEBCO Sheet G.08, the "oceanic scale" (4 inches per degree longitude, Mercator projection) sounding compilation sheets maintained at SIO were augmented by shipboard data from the following sources (individuals responsible for contributing the data are named in parenthesis):

1. Principal sources: collector sheets

1.1 GEBCO Collected Soundings Sheets (1:1 million scale, Mercator) maintained by Volunteering Hydrographic Offices with geographic responsibilities within the region:

a) U.K. Hydrographic Department, Taunton: complete collection, including Southern Ocean, updated to 1988-1989: (Nigel Gooding, Brian Harper)

b) South Africa Hydrographic Office, Tokai, Cape: complete collection variously updated to 1981-1983: (C.G.H. Wagenfeld, D.B. MacPherson)

c) Hydrographic Office, Royal Australian Navy, Garden Island and Wollongong, NSW: 57 sheets, variously updated to 1971-1989: (Mark A. Bolger)

1.2 USNOO Bay St. Louis, Mississippi: USNS Wilkes, 1977-1979, 1981-82 operations: (Francis Marchant, Luther Little)

2. Principal sources: digital files

2.1 Government agencies:

a) Australian Antarctic Division, Kingston, Tasmania: R/V Aurora australis 1990's sub-Antarctic cruises: (Henk Brolsma, Lee Belbin, Ursula Ryan)

b) Australian Geological Survey Organisation (formerly Bureau of Mineral Resources), Canberra:

1) 979-1995 tracks and soundings of geophysical survey ships in the Australian EEZ, on Kerguelen Plateau and the Antarctic margin: (Chris Johnston, Millard Coffin)

2) SOJOURN 7 and TASMANTE cruises: (Neville Exon, Peter Hill)

c) Australian CSIRO Division of Oceanography, Hobart, Tasmania: R/V Franklin 1987-1998 tracks and soundings on continental margins, EEZ and near Christmas Island: (Bernadette Heaney, Data Librarian and Terry Byrne)

d) Geological Survey of Japan, Marine Geophysics Section, Marine Geology Department: bathymetric data collected during JNOC (Japan National Oil Corporation) survey cruises off Antarctica, R/V Hakurei Maru 1980-1995: (Takemi Ishihara, JGS)

e) Japanese (JARE, ANTAC) and Soviet (R/V Ob, 1957-58) research vessel soundings off Antarctica (received via US National Geophysical Data Center, Boulder, Colorado)

f) South Africa Hydrographic Office, Tokai, Cape: throughout S.A. GEBCO Area of Responsibility, 1990-1998: (Sidney Osborne, B.D. Law, Tony Pharaoh)

2.2 Laboratories and academic institutions:

a) Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven: R/V Polarstern pre-1998 soundings in the sub-Antarctic between 10°W and 40°E: (Hans Werner Schenke)

b) L'Ecole et Observatoire de Physique du Globe de Strasbourg: track and soundings of R/V Marion Dufresne and R/V l'Atalante in central and eastern Indian Ocean, 1980-1998: (Marc Munschy, Marc Schaming, Roland Schlich, Marie-Odile Boulanger)

c) Institut Universitaire European de la Mer, Universite de Bretagne Occidentale, Plouzane: 1998 MAGOFOND 2 cruise of R/V Marion Dufresne: (Jerome Dyment); R/V Marion Dufresne 110 and R/V Atalante TASMANTE 1994 cruises: (J.-Y. Royer)

d) Laboratoire de Geophysique Marine, Institut de Physique du Globe de Paris, Paris VI: R/V Marion Dufresne and R/V L'Atalante 1982-1995 sounding data in the western and east-central Indian Ocean: (Philippe Patriat, Jacques Segoufin)

e) R/V Melville (SIO) soundings in the southeast Indian Ocean, 1994-1995: contributions from Lamont-Doherty Earth Observatory, New York: (Christopher Small, James Cochran, Carl Brenner); Oregon State University: (David Christie); University of Washington: (Jean-Christophe Sempere)

f) Geological Data Center, Scripps Institution of Oceanography, La Jolla, California: "Alliance exotique" (IODCP) files, 1987-2001: (Virginia Wells)

3. Secondary sources: digital files

a) Bullard Laboratories, University of Cambridge, UK: 1986-1987 cruises of RRS Charles Darwin, RRS Shackleton: (Carol Williams)

b) Bundesamt fur Seeschiffahrt und Hydrographie, Hamburg: 1997 tracks and soundings being compiled for IOC's International Bathymetric Chart of the Western Indian Ocean: (Hartmut Kluger)

c) Hydrographic Office, Taunton, UK: (Gordon Taylor)

d) National Institute of Water and Atmospheric Research Ltd, Wellington New Zealand: 1997: partial tracks of 15 NIWA cruises between 166°E and 170°E: (Ian Wright)

e) Netherlands Institute for Sea Research, Texel: R/V Tyro 1992-1993 cruise, Arabian Sea: (C.N. van Bergen Henegouw)

f) Ocean Research Institute, Tokyo: 1999 tracks and soundings from ORI's FUJI and INDOYO cruises: (Kensaku Tamaki, Hiromi Fujimoto, Tomohiro Yamaashi) also (Catherine Mevel, Laboratoire de Petrologie, Mineralogie, Metallogenie, Paris VI)

g) Southampton Oceanography Centre, Southampton, UK: RRS Discovery cruises 199, 200, 207, 208 southwest Indian Ocean: (Martin Saunders, Peter Hunter)

h) University of Texas Institute of Geophysics, Austin: tracks and soundings of Australia's R/V Rig Seismic (1994) and of R/V Maurice Ewing (1996), Macquarie Ridge Complex: (Millard Coffin, Christina Massell)

i) Woods Hole Oceanographic Institution, Massachusetts: 1987 RRS Charles Darwin Durban-Fremantle cruise: (John Toole)

j) National Geophysical Data Centre, Boulder, Colorado: Acquisition updates 1995-1998

ANNEX K.9: GEBCO Sheet G.09
(Waters around New Zealand)

REGIONAL BATHYMETRIC CHART OF NEW ZEALAND (compiled 1997)

Authors:	Lionel Carter, Greg Foster, Richard Garlick, John Mitchell and Ian Wright – Charting Around New Zealand (CANZ) Group, National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand.
Digitised by:	Nichola Litchfield (contours) and Dave Cook (tracklines), CANZ Group, NIWA
Sheet Limits:	24°S to 57°30'S; 157°E to 167°W
Scale:	contours compiled and digitised on Mercator sheets at a scale of 1:1 million
Horizontal Datum:	WGS-84
Contour Units:	bathymetric depth in corrected metres
Contours present:	0m, 50m, 100m, 150m, 200m, 250m and at 250m intervals thereafter down to 10,000m
Coastline Source:	NIMA World Vector Shoreline (1:250,000 scale)
Published Chart:	CANZ Group (1997), 'New Zealand Region Bathymetry', 1:4,000,000 scale at 46°S on Mercator projection, NIWA Chart, Miscellaneous Series No. 73, National Institute of Water and Atmospheric Research, Wellington, New Zealand

Geographic Coverage:

In the edgematching of this sheet with GEBCO sheet G.08, the bathymetry was taken from sheet G.08 for the following areas:

24°-31°S,157°-158.5°E; 47°-54°S,157°-165°E; 54°-57.5°S,157°-163.5°E

PREPARATION OF GEBCO SHEET G.09

The bathymetry was compiled by NIWA at a scale of 1:1 million using a series of 18 separate Ocean Plotting Sheets on which the soundings were plotted. Each author (as listed above) worked on the interpretation and contouring of 3-4 sheets each and gravity data were used to assist in the interpretation. The resulting contours (at intervals of 250m) were then digitised and used in the production of the 1:4 million scale chart. The digitised contours and digital trackline control data were also submitted to BODC as the base for GEBCO sheet G.09.

The bathymetry was compiled from data held at:

National Institute of Water and Atmosphere (NIWA);

Hydrographic Office of the Royal New Zealand Navy;

US National Geophysical Data Centre;

South Pacific Applied Geoscience Commission (Fiji);

from published scientific papers;

and from recent swath bathymetric surveys funded by Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER), France, NIWA and Seabed Mapping New Zealand Ltd.

The shallow water contours (50m, 100m, 150m and 200m) were delivered to BODC in digital form from the NIWA Coastal Database, compiled by Kevin MacKay. The database is made up of the digitised contours from the NIWA coastal (1:200,000) chart series.

ANNEX L

Supporting Documentation for GEBCO Fifth Edition sheets used in the GEBCO Digital Atlas

General information on the production of the GEBCO Fifth Edition may be found in Annex B while information on the digitization of the GEBCO Fifth Edition sheets for inclusion in the GEBCO Digital Atlas is given in Annex C.

This Annex contains supporting information to accompany those GEBCO Fifth Edition sheets still used in the GEBCO Digital Atlas. It should be noted that the bathymetry from GEBCO sheets 5.09, 5.13 and 5.17 has now been superseded by revised bathymetry contained in GEBCO update sheets G.01 and G.08. Annexes L.9, L.13 and L.17 are therefore missing.

In the Centenary Edition of the GDA, sections of the bathymetry from the Fifth Edition sheets have been replaced by the revised bathymetry in the update sheets G.01 to G.09. The extent of this revision is indicated in parenthesis below.

Annex L.1: Sheet 5.01 (major updating)
Annex L.2: Sheet 5.02 (partial updating)
Annex L.3: Sheet 5.03 (partial updating)
Annex L.4: Sheet 5.04 (major updating)
Annex L.5: Sheet 5.05 (major updating)
Annex L.6: Sheet 5.06 (partial updating)
Annex L.7: Sheet 5.07
Annex L.8: Sheet 5.08 (major updating)
Annex L.10: Sheet 5.10 (major updating)
Annex L.11: Sheet 5.11
Annex L.12: Sheet 5.12 (major updating)
Annex L.14: Sheet 5.14 (major updating)
Annex L.15: Sheet 5.15
Annex L.16: Sheet 5.16 (major updating)
Annex L.18: Sheet 5.18 (major updating)

ANNEX L.1: GEBCO Sheet 5.01*

*MAJOR UPDATE NOTE: The bathymetry in the area of GEBCO sheet 5.01 from 47°N to 64°N; 0° to 6°E has been replaced by the revised bathymetry contained in GEBCO sheet G.02. North of 64°N, it has been replaced by the revised bathymetry of GEBCO sheet G.01.

GEBCO sheet 5.01 was published in April 1978 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinator: Johannes Ulrich, Institut für Meereskunde an der Universitat Kiel, Germany

Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published chart:	GEBCO SHEET 5.01 (April 1978)
Projection:	Mercator Scale: 1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	46°40'N
Western Limit:	000°00'E
Northern Limit:	72°00'N
Eastern Limit:	090°00'E
Digitised by:	Bureau Gravimetrique International, Toulouse, France, in collaboration with Institut Geographique National, Paris, France, and the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0m, 50m, 100m and at 100m intervals thereafter down to 3700m

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.01 CONTOURS

Bathymetric contours are based on collected oceanic soundings up to 1975 from the German Hydrographic Office, Hamburg, and additional data, contour maps and nautical charts from Norway, USSR, Sweden, Germany, UK and USA.

GEBCO Collected Soundings Sheets:

GEBCO Plotting Sheets 30 (1972) and 17 (1972) from UK Hydrographic Office.

GEBCO Plotting Sheets 10 (1972) and 18 (1972) from Swedish Hydrographic Office.

GEBCO Plotting Sheets 9 (1972), 3 (1972), 4 (1972) and 4A (1970) from German Hydrographic Office.

Nautical Charts:

Norwegian nautical charts No. 301 (INT 140), 307, 308, 309, 310, 311, 319, 320, 321, 322, 323, 324, 325, 551, 552, 553, 557, 558, 559.

British nautical charts No. 3180, 3181, 2963, 2962.

USSR nautical charts No. 601, 650, 696.

German nautical charts No. 1000 (INT 1401), 1001 (INT 1402), 241, 242.

International nautical charts INT 140 (Norges Sjokartverk) and INT 1403 (Hydrografie van Nederlande).

Contour Charts and Bathymetric Maps:

Sounding map Norges Sjokartverk (1975), unpublished.

Bathymetric chart NTNF's Continental Shelf Division, 1:1,000,000 (1975), Norway.

Contour chart Norges Sjokarterk No. 7016, 1:250,000, NTNF's Continental Shelf Division (1974, 1975).

Data of soviet oceanographic expeditions obtained in accordance with programmes of international co-operation.

Norwegische See, Tiefenkarte 1:200,000, "Meteor" Forschungsergebnisse, Reihe A, No. 12 (1972).

Special Sounding map from Lamont-Doherty Geological Observatory, USA, unpublished.

ANNEX L.2: GEBCO Sheet 5.02*

*MINOR UPDATE NOTE: The bathymetry in the area of GEBCO sheet 5.02 north of 64°N has been replaced by the bathymetry contained in GEBCO sheet G.01

GEBCO sheet 5.02 was published in March 1980 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinator:	Gleb B. Udintsev, Institute of Physics of the Earth, Moscow, USSR
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.02 (March 1980)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsiod:	International 1924 (Hayford)
Southern Limit:	46°40'N
Western Limit:	090°00'E
Northern Limit:	72°00'N
Eastern Limit:	180°00'E
Digitised by:	Head Department of Navigation and Oceanography, St. Petersburg, Russia, in collaboration with the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0m, 200m, 500m and at 500m intervals thereafter down to 8500m. In some areas the 50m and 100m contours are also included.
Comments:	The digitised data for this chart were edgematched with that for GEBCO sheets 5.06 and 5.03 with the result that some of the contours at the sheet boundaries may be displaced slightly from their positions on the published chart. As the digital data for GEBCO sheet 5.06 were supplied from a regularly updated data base and not digitised from GEBCO sheet 5.06, it proved difficult to achieve an edgematch with digital data for GEBCO sheet 5.02, most notably in the area of the Emperor Seamount Chain from 169° to 175°E, 46° to 47°N.

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.02 CONTOURS

a) GEBCO 1:1,000,000 COLLECTED SOUNDINGS SHEETS:

Japan: 1408N, 1409N, 1410N, 1411N, 1508N, 1509N, 1510N, 1511N, 1609N, 1610N, 1612N, 1708N, 1709N, 1710N, 1711N, 1712N, 1808N, 1810N, 1811N, 1812N, 1813N.

USA: 1909N, 1910N, 1911N, 1912N, 1913N, 2009N, 2010N, 2011N, 2109N, 2110N, 2111N, 2209N, 2210N, 2211N, 2309N.

Data obtained by research vessels of Institute of Oceanology, Academy of Sciences, USSR.

b) BATHYMETRIC MAPS:

Scholl, D., Tau Rho Alpha, Marlow, M.S., Buffington, E.G., 1974. Base map of the Aleutian-Bering Sea region, scale 1:2,500,000.

Nichols, H. and Perry, R.B., 1966. Bathymetry of the Aleutian Arc, Alaska. US Dept. of Commerce. Environmental Science Services Admin., Coast and Geodetic Survey. Mon. 3, Plate 1 and 2, scale 1:400,000.

Heezen, B.C. and Tharp, M., 1975. Map of the Arctic Region. American Geographical Society, New York, scale 1:5,000,000 at 71°N.

ANNEX L.3: GEBCO Sheet 5.03*

* MINOR UPDATE NOTE: The bathymetry in the area of GEBCO sheet 5.03 north of 64°N has been replaced by the bathymetry contained in GEBCO sheet G.01

GEBCO sheet 5.03 was published in March 1979 by the Canadian Hydrographic Service under the authority of the IHO and IOC

Scientific Coordinators:	G. Leonard Johnson, Office of Naval Research Arlington, USA; and David Monahan, Canadian Hydrographic Service Ottawa, Canada
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.03 (March 1979)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	46°40'N
Western Limit:	180°00'W
Northern Limit:	72°00'N
Eastern Limit:	090°00'W
Digitised by:	NERC Unit for Thematic Information Systems, Reading, UK, in collaboration with the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart, except for the bathymetric contours in the western part of Hudson Bay from the area 90° to 95°W, 55° to 65°N. This area is covered in the digital data for GEBCO sheet 5.04.
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0m, 200m, 500m and at 500m intervals thereafter down to 6000m, with two additional contours at 7000m. However, for many areas, intermediate contours are also included and the digital data set will be found to include contours at the following depths: 50m, 100m, 300m, 400m and at 200m intervals thereafter down to 6000m, with an additional contour at 4900m.
Comments:	The digitised data for this chart were edgematched with that for GEBCO sheets 5.02 and 5.07 with the result that some of the contours at the sheet boundaries may be displaced slightly from their positions on the published chart.

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.03 CONTOURS

SCIENTIFIC LITERATURE:

Anonymous, Bathymetric base maps: The US Naval Oceanographic Office and Defense Mapping Agency, Hydrographic Center.

Anonymous, 1971a, Bathymetric atlas of the northeastern Pacific Ocean: Prepared by Scripps Institution of Oceanography under the direction of T.E. Chase and H.W. Menard, H.O. Pub. No. 1303, US Naval Oceanog. Office.

Anonymous, 1971b, Bathymetric atlas of the northcentral Pacific Ocean: Prepared by Scripps Institution of Oceanography under the direction of T.E. Chase and H.W. Menard, H.O. Pub. No. 1302-S, US Naval Oceanog. Office.

Barr, S.M. and Chase, R.L., 1974, Geology of the northern end of Juan de Fuca Ridge and sea-floor spreading. Can. J. Earth Sci., 11, 1384-1406.

Mammerickx, J., 1970, Morphology of the Aleutian Abyssal Plain. Geol. Soc. Amer. Bull., 81, 3457-3464.

Mammerickx, J. and Tayler, I.L., 1971, Bathymetry of the Pioneer Survey Area, Scripps Institution of Oceanography Sp. Chart No. 1.

Nichols, H., and Perry, R.B., 1966, Bathymetry of the Aleutian Arc, Alaska: US Dept. Commerce. Environmental Sci. Services Admin., Coast and Geod. Survey Mon. 3, scale 1:400,000, 6 maps.

Nichols, H., Perry, R.B. and Kofoed, J.W., 1964, Bathymetry of Bowers Band, Bering Sea: Jour. Surveying and Mapping, 24, 443-448.

Schumaker, G.M., 1976, Bathymetric map of the Aleutian Trench and Bering Sea. Map 76-821, US Geological Survey, Menlo Park, Calif.

Schumaker, G.M. 1976, Bathymetric map of the Gulf of Alaska. Map 76-822, US Geological Survey, Menlo Park, Calif.

Schumaker, G.M., 1976, Bathymetric map of the Chukchi Sea and Arctic Ocean. Map 76-823, US Geological Survey, Menlo Park, Calif.

Sharma, G.D. 1975, Contemporary Epicontinental Sedimentation and Shelf Grading in the southeast Bering Sea. Geol. Soc. of Amer. Spec. Paper 151, 33-48.

Stewart, R.J. 1976, Turbidities of the Aleutian abyssal plain: Mineralogy, provenance, and constraints for Cenozoic motion of the Pacific plate. Geol. Soc. of Amer. Bull., 87, 793-808.

ANNEX L.4: GEBCO Sheet 5.04*

*MAJOR UPDATE NOTE: The bathymetry in the area of GEBCO Sheet 5.04 from 47°N to 64°N; 37°W to 6°E has been replaced by the revised bathymetry contained in GEBCO Sheet G.02. North of 64°N, it has been replaced by the revised bathymetry of GEBCO sheet G.01. In the narrow border 46°40'N to 48°N from 0° to 13°W, the bathymetry has been replaced by data from GEBCO Sheets G.02 and G.04.

GEBCO sheet 5.04 was published in April 1978 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinators:	Anthony S. Laughton, Institute of Oceanographic Sciences, Wormley, United Kingdom; and David Monahan, Canadian Hydrographic Service, Ottawa, Canada
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.04 (April 1978)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	46°40'N
Western Limit:	095°00'W
Northern Limit:	72°00'N
Eastern Limit:	000°00'E
Note:	The area from 90° to 95°W is only covered between 55° and 65°N
Digitised by:	Bureau Gravimetrique International, Toulouse, France, in collaboration with Institut Geographique National, Paris, France, and the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0m, 200, 500m and at 500m intervals thereafter down to 4500m. However, for many areas, intermediate contours are also included and the digital data set will be found to include contours at the following depths: 50m, 100m, 150m and at 100m intervals from 200m down to 4900m.

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.04 CONTOURS

GEBCO 1:1,000,000 COLLECTED SOUNDINGS SHEETS:

Canada, Canadian Hydrographic Service: 1, 5C, 6, 12A, 12B, 13, 14, 25A, 25B, 26, 27, 40.

France, Service Hydrographique et Oceanographie de la Marine: 39, 40, 41, 42, 43.

Germany, Deutsches Hydrographisches Institut: 2, 3, 7, 8, 9, 14, 15, 27, 28.

Iceland Hydrographic Service: Charts 25, 26.

UK, Hydrographic Office: 7, 8, 9, 14, 15, 16, 27, 28, 29, 40, 41, 42, 43.

USA, Defense Mapping Agency: 38, 39.

UNPUBLISHED SURVEY DATA OR CONTOURS:

Canada, Canadian Hydrographic Service.

Denmark, Royal Danish Hydrographic Office.

German cruises 1970 and 1972 by R/V "Meteor" and 1971 by R/V "Komet".

UK cruises 1973 and 1974 of RRS "Shackleton" by Durham University.

UK Institute of Oceanographic Sciences, 1:1,000,000 bathymetric charts 2, 3, 7, 8, 9, 14, 15, 16, 27, 28, 29, 40, 41, 42, 43.

UK Hydrographic Department.

US Defense Mapping Agency.

USSR Cruises 11 and 15 of R/V "Kurchatov".

USSR site surveys for DSDP Leg 38.

SCIENTIFIC LITERATURE:

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Laughton, A.S., Roberts, D.G. and Graves, R., 1975, Deep-Sea Research, 22, 791-810.

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Talwani, M., Poppe, B., Hastings, J. and Aitken, T., 1974, LDGO technical report. Lamont-Doherty Survey of the World Ocean. (Talwani ed.).

Talwani, M., Windisch, C.C. and Langseth, M.G., 1971, J. Geophys. Res. 76 (2), 473-517.

Ulrich, J., 1962, Deutsch. Hydrog. Zeit. 6, 15 pp.

Ulrich, J., 1960, Kieler Meeresforshungen 16, 155-163.

van der Linden, W.J., Fillon, R.H. and Monahan, D., 1976, Geol. Surv. Can. Paper 75-40, 31 pp.

Vogt, P.R. and Avery, O.E., 1974, J. Geophys. Res. 79 (2), 363-389.

Vogt, P.R. and Johnson, G.L., 1972, Earth and Plan. Sci. Letters. 15, 248-254.

Vogt, P.R. and Johnson, G.L., 1975, J. Geophys. Res. 80, 1399-1428.

Vogt, P.R., Johnson, G.L., Hollombe, T.L., Gilg, J.G. and Avery, O.E., 1971, Tectonophysics 12 (3), 211-234.

ANNEX L.5: GEBCO Sheet 5.05*

*MAJOR UPDATE NOTE: The bathymetry of virtually all of the area of GEBCO sheet 5.05 has been replaced by the revised bathymetry contained in GEBCO sheet G.08. Essentially all that remains from sheet 5.05 is the bathymetry of the Red Sea.

GEBCO sheet 5.05 was published in April 1975 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinator:	Anthony S. Laughton, Institute of Oceanographic Sciences, Wormley, United Kingdom
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.05 (April 1975)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	00°00'N
Western Limit:	006°00'W
Northern Limit:	46°40'N
Eastern Limit:	100°00'E
Note:	The area from 90° to 100°E is only covered between 0° and 32°N. The area 0° to 6°W is only covered between 29° and 42°N.
Digitised by:	Bureau Gravimetrique International, Toulouse, France, in collaboration with Institut Geographique National, Paris, France, and the British Oceanographic Data Centre.
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0m, 200m, 500m and at 500m intervals thereafter down to 5000m. In some areas additional contours are also present and the digital data set will be found to include contours at the following depths: 50m, 100m and 700m.

ANNEX L.6: GEBCO Sheet 5.06*

*UPDATE NOTE: The bathymetry of the area of GEBCO sheet 5.06 in the Indian Ocean (i.e. west of 99°E and south of the line joining the points 99°E, 10°N and 105°E, 0°N) and the Eastern Archipelagic Seas (south of 4°N between 115°E to 136°E) has been replaced by the revised bathymetry contained in GEBCO sheet G.08.

GEBCO sheet 5.06 was published in April 1979 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinator:	Yoshio Iwabuchi, Hydrographic Department (Marine Safety Agency), Tokyo, Japan
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.06 (April 1979)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	00°00'N
Western Limit:	090°00'E
Northern Limit:	46°47'N
Eastern Limit:	180°00'E
Digitised by:	Japan Oceanographic Data Center, Tokyo, Japan, in collaboration with the British Oceanographic Data Centre
Geographic Area Digitised:	The digital data in this file covers the area 90° to 180°E, 0° to 46°40'N

Please note:

1) The bathymetric contours for most of this area were kept updated by Dr. Iwabuchi at the Japan Oceanographic Data Center and a new compilation was produced in 1984 in the form of a paper atlas published on Mercator projection at a scale of 1:1 million covering the area 120° to 180°E, 0° to 46°40'N. Thus, rather than digitize the outdated information published as GEBCO sheet 5.06 in 1979, it was decided to make use of digital files already available from JODC.

2) The digital data for the area 120° to 180°E, 0° to 46°40'N were supplied by JODC from a data base, digitised from source material at a scale of 1:1 million. The source material for this area is covered in the paper atlas published in 1984 and supplied by JODC.

3) A 1:1 million digital data set covering the area 100° to 120°E, 0° to 46°40'N was also supplied by JODC. Quality control work on the digital data sets supplied by JODC was carried out at BODC. The volume of data was reduced using software based on the Douglas-Peucker generalization algorithm. A lateral tolerance factor of 0.08mm was

used. The use of this filtering algorithm reduced the size of the data file to approximately 11.2 percent of its original volume.

4) The digital data for the area 90° to 100°E, 0° to 46°40'N were digitised at BODC from GEBCO sheet 5.06 published in April 1979.

5) The 50m and 100m contours in the region 120° to 129°E, 23° to 39°N, i.e. the area of the East China Sea and Yellow Sea, were absent in the digital data set supplied by JODC and were digitised by BODC from GEBCO sheet 5.06.

Contour Units: bathymetric depth in corrected metres

Contours Present: 0, 200m, 500m and at 500m intervals thereafter down to 10500m. However, in some areas, the 50m and 100m contours are also included.

Comments: As the digital data for the area 100° to 180°E, 0° to 46°40'N were not digitised from GEBCO sheet 5.06, it proved difficult to achieve an accurate match at the boundaries with the surrounding GEBCO sheets. This was due to variations in the track line control shown by the GEBCO sheets and in the paper atlas supplied by JODC. This is most notable at:

1) 169° to 175°E, 46° to 47°N, i.e. the area of the Emperor Seamount Chain.
2) 150° to 151°E, 0°N
3) 135° to 139°E, 0°N
4) 9°30' to 10°N, 180°E
5) 34°30' to 35°30'N, 180°E
6) 41°30' to 43°N, 180°E

ANNEX L.7: GEBCO Sheet 5.07

*MINOR UPDATE NOTE: The bathymetry of the area of GEBCO sheet 5.07 north of 15°N and east of 101°W has been replaced by the revised bathymetry contained in GEBCO Sheet G.03.

GEBCO sheet 5.07 was published in March 1982 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinators:	Jacqueline Mammerickx and Stuart M. Smith, Geological Research Division, Scripps Institution of Oceanography, La Jolla, USA
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.07 (March 1982)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	00°00'N
Western Limit:	180°00'W
Northern Limit:	46°40'N
Eastern Limit:	077°00'W
Note:	The area from 77° to 90°W is only covered south of a line joining the points 15°N 90°W and 8°16'N 77°W.
Digitised by:	NERC Unit for Thematic Information Systems, Reading, UK, in collaboration with the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart, except for the area north of Central America, i.e. the area north of a line joining the points 16°N 90°W, 8°16'N 82°W, 9°15'N, 79°W. The digital data for this area is covered in GEBCO sheet 5.08. The digital bathymetric contour data for the western part of the Gulf of Mexico, the area 90° to 98°W, 18° to 30°N, is also omitted. This area is covered in the digital data for GEBCO sheet G.03.
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0, 200m, 500m and at 500m intervals thereafter down to 7000m. However, for many areas, intermediate contours are also included and the digital data set will be found to include additional contours at the following depths: 100m, 800m, 1600m, 1800m, 2100m and at 100m intervals thereafter down to 5800m, with one additional contour at 6100m.

Comments: The digitised data for this chart were edgematched with that for GEBCO sheets 5.03, 5.06, 5.10 and 5.11 with the result that some of the contours at the sheet boundaries may be displaced slightly from their positions on the published chart. As the digital data for GEBCO sheet 5.06 were supplied from a regularly updated data base and not digitised from the original sheet, it proved difficult to achieve an edgematch with the digital data for GEBCO sheet 5.07, most notably in the following areas:

1) 34°30' to 35°30'N, 180°W
2) 41°30' to 43°N, 180°W

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.07 CONTOURS

Defense Mapping Agency, Hydrographic/Topographic Center, Washington, D.C.
Hawaii Institute of Geophysics, University of Hawaii, Honolulu, Hawaii.
Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York.
National Geophysical and Solar Terrestrial Data Center, Boulder, Colorado.
Naval Oceanographic Office, NSTL Station, Bay St. Louis, Mississippi.
School of Oceanography, Oregon State University, Corvallis, Oregon.
Scripps Institute of Oceanography, University of California, San Diego, California.

SCIENTIFIC LITERATURE:

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ANNEX L.8: GEBCO Sheet 5.08*

*MAJOR UPDATE NOTE: The bathymetry of four regions within the area of GEBCO sheet 5.08 have been replaced by the revised bathymetry contained in:

a) GEBCO sheet G.03 covering Gulf of Mexico, Caribbean and the North Atlantic off Florida and the Caribbean; from 15°N to 33°N and west of 61°W (but only 69°W north of 24°N)
b) GEBCO sheet G.04 (essentially north of 32°N and east of 16°W covering the Bay of Biscay and the Atlantic off the Iberian Peninsula)
c) GEBCO sheet G.05 covering an irregular area within the North East Atlantic between 18°N and 35°N; 14°W to 47°W
d) GEBCO sheet G.06 south of 12°N and east of 22°W

GEBCO sheet 5.08 was published in January 1982 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinators:	Roger C. Searle, Institute of Oceanographic Sciences Wormley, United Kingdom; David Monahan, Canadian Hydrographic Service, Ottawa, Canada; and G. Leonard Johnson, Office of Naval Research, Arlington, USA
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.08 (January 1982)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	00°00'N
Western Limit:	098°00'W
Northern Limit:	46°40'N
Eastern Limit:	010°00'E
Note:	The area from 90 to 98°W is only covered between 18 and 30°N, while the area from 0° to 10°E is only covered between 0° and 7°N.
Digitised by:	Bureau Gravimetrique International, Toulouse, France, in collaboration with Institut Geographique National, Paris, France and the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart; except for the area 70°W to 10°E, 0° to 7°N which is covered in the digital data for GEBCO sheet 5.12. The digital data for the area south of Central America, i.e. the area south of a line joining the points 16°N 90°W, 8°30'N 82°W, 9°15'N 79°W, 8°16'N 77°W, is also omitted and is covered in GEBCO sheet 5.07.

Contour Units:	bathymetric depth in corrected metres
Contours Present:	0m, 200m, 500m and at 500m intervals thereafter down to 8000m. However, for areas away from the Mid-Atlantic Ridge, intermediate contours are also included and the digital data set will be found to include contours at the following depths: 50m, 100m and at 100m intervals thereafter down to 6000m.

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.08 CONTOURS

SOUNDINGS ADDITIONAL TO GEBCO 1:1,000,000 COLLECTED SOUNDINGS SHEETS:

B.J. Collette, unpublished soundings.

B.C. Heezen and M. Tharp, working sheets (4 inches per degree) for GEBCO chart 5.12, 0°N to 7°N.

RRS "Discovery" cruises 54, 73, 84, 91.

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ANNEX L.10: GEBCO Sheet 5.10*

*MAJOR UPDATE NOTE: The bathymetry in the area of GEBCO sheet 5.10 south of 24°S and west of 167°W has been replaced by revised bathymetry contained in GEBCO sheets G.08 and G.09.

GEBCO sheet 5.10 was published in March 1982 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinators:	David Monahan, Canadian Hydrographic Service, Ottawa, Canada; Robin H.K. Falconer, New Zealand Oceanographic Institute, Wellington, New Zealand; and Marie Tharp, Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York, USA
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.10 (March 1982)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	46°40'S
Western Limit:	110°00'E
Northern Limit:	00°00'S
Eastern Limit:	160°00'W
Digitised by:	NERC Unit for Thematic Information Systems, Reading, UK, in collaboration with the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0m, 200m, 500m and at 500m intervals thereafter down to 10500m. However, for many areas, intermediate contours are also included and the digital data set will be found to include contours at the following depths: 50m, 100m, 300m, 400m, 4600m, 4800m and at 100m intervals thereafter down to 5900m.
Comments:	The digitised data for this chart were edgematched with that for GEBCO sheets 5.06, 5.07, 5.11 and 5.14 with the result that some of the contours at the sheet boundaries may be displaced slightly from their positions on the published chart. As the digital data for GEBCO sheet 5.06 were supplied from a regularly updated data base and not digitised from the original sheet, it proved difficult to achieve an edgematch with

the digital data for GEBCO sheet 5.10, most noticeably in the following areas:

1) 135° to 139°E, 0°N
2) 150° to 151°E, 0°N

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.10 CONTOURS

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ANNEX L.11: GEBCO Sheet 5.11

GEBCO sheet 5.11 was published in March 1980 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinators:	Jacqueline Mammerickx, Stuart M. Smith, Geological Research Division, Scripps Institution of Oceanography, La Jolla, USA
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.11 (March 1980)
Projection:	Mercator Scale: 1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	46°40'S
Western Limit:	160°00'W
Northern Limit:	00°00'S
Eastern Limit:	070°00'W
Digitised by:	NERC Unit for Thematic Information Systems, Reading, UK, in collaboration with the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0m, 200m, 500m and at 500m intervals thereafter down to 8000m. However, for many areas, intermediate contours are also included and the digital data set will be found to include contours at the following depths: 100m, 1200m, 1600m, 1700m, 1800m, 2200m, 2400m and at 100m intervals thereafter down to 5700m.
Comments:	The digitised data for this chart were edgematched with that for sheets 5.07, 5.10, 5.15 and 5.16 with the result that some of the contours at the sheet boundaries may be displaced slightly from their positions on the published chart.

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.11 CONTOURS

SOURCES OF DETAILED SURVEYS:

Atlantic Oceanographic Laboratory, Dartmouth, Nova Scotia, Canada.
Centre National pour l'Exploitation des Oceans, Brest, France.
Hawaii Institute of Geophysics, University of Hawaii, Honolulu, Hawaii, USA.
Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York, USA.

National Geophysical and Solar Terrestrial Data Centre, Washington, D.C., USA.

Ocean Research Institute, University of Tokyo, Tokyo, Japan.

School of Marine and Atmospheric Science, University of Miami, Miami, Florida, USA.

School of Oceanography, Oregon State University, Corvallis, Oregon, USA.

Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California, USA.

Shirshov Institute of Oceanology, Academy of Science, Moscow, USSR.

Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA.

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ANNEX L.12: GEBCO Sheet 5.12 (Revised)*

*UPDATE NOTE: The bathymetry of two regions within the area of GEBCO sheet 5.12 (revised)have been replaced by the revised bathymetry contained in GEBCO sheets G.06 (off equatorial Africa; east of 22°W north of the equator and east of 3°E north of 8°S) and G.08 (south-east Atlantic; south of 24°S and east of 12°W)

The revised version of GEBCO sheet 5.12 was published in 1994 by the Canadian Hydrographic Service under the authority of the IHO and IOC. The sheet was published directly from material digitised by BODC from contour compilations provided in hard copy form by the scientific coordinators.

Scientific Coordinators:	Norman Cherkis, Naval Research Laboratory, Washington, USA; Gleb Udinstev, Vernadsky Institute of Geochemistry Geochemistry, Moscow, Russia; Robin Falconer and Jane Handley, GeoResearch Associates, Waikanae, New Zealand; Carl Brenner, Lamont-Doherty Geological Observatory, Columbia University, New York; and Peter Hunter, Institute of Oceanographic Sciences Deacon Laboratory, Wormley, UK
Digitised by:	The British Oceanographic Data Centre
Geographic Area Digitised:	The digital data covers the area 70°W to 20°E, 7°N to 50°S and was prepared from bathymetric contours compiled on Mercator charts at a scale of 1:5,737,447 at the equator.
Contour Units:	bathymetric depths in corrected metres
Contours Present:	0, 200m, 500m and at 500m intervals thereafter down to 7000m. However in some areas bathymetric contours at the following depths are found: 10m, 20m, 40m, 50m, 60m, 80m, 100m, 300m, 400m, 1200m and at 200m intervals thereafter to 6000m. Additional contours are also found at 1300m, 2300m and at 100m intervals from 2900m down to 6100m.

Originators of Bathymetric Contours:

1) Norman Cherkis: 00°00'S to 40°00'S; 70°00'W to 20°00'E
2) Carl Brenner: 40°00'S to 50°00'S; 70°00'W to 20°00'E
3) Gleb Udintsev: 00°00'N to 05°00'N; 24°00'W to 36°00'W
4) Robin Falconer and Jane Handley: Interpolation of contours at 500 metre intervals for 03°00'S to 40°00'S; 70°00'W to 20°00'E
5) The bathymetric contours for 00°00'N to 07°00'N; 10°00'E to 40°00'W, not covered by any of the above, were taken from GEBCO sheet 5.08.
6) Additional contours were compiled by Peter Hunter.

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.12 CONTOURS

BATHYMETRY BETWEEN 03°00'S AND 40°00'S BASED ON:

Cherkis, N.Z., Fleming, H.S. & Brozena, J.M., 1989. Bathymetry of the South Atlantic Ocean 03°00'S to 40°00'S. Map and Chart Series MCH-069, The Geological Society of America, Boulder, Colorado, USA.

DETAILED SURVEYS AND COMPILATIONS:

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2. Udintsev, G.B., 1988. R/V "Akademik Nikolai Strakhov" cruises: 7-1988, 11-1990 and 12-1991, Equaridge Programme (Multi-beam surveys). Russian Academy of Sciences, Moscow.

3. Martin, L., 1970. Institute of Geological Sciences, London, Report No. 70/16, 105-119; and: Martin, L., 1977. Travaux et Documents de l'O.R.S.T.O.M., No. 61, Paris, 265 pp.

4. Thomas, M.V., 1989. A Geophysical Study of the Romanche Transform and Surrounding Areas of the Mid-Atlantic Ridge. PhD Thesis, Department of Geological Sciences, University College of London, September 1989, 402 pp.

5. R/V "Robert D. Conrad" cruise RC3003, 10 February to 12 March 1989 (Seabeam survey).

6. R/V "Robert D. Conrad" cruises: RC2515, RC2601 and RC2602, 26 December 1984 to 26 February 1985 (Seabeam surveys).

7. R/V "Robert D. Conrad" cruises: RC2905, 3 April to 26 May 1988 and RC3003, 10 February to 12 March 1989 (Seabeam surveys).

8. R/V "Robert D. Conrad" cruise RC2905, 3 April to 26 May 1988 (Seabeam survey).

9. Pogrebitskiy, Y.Y. and Naryshkin, G.D., 1989. Angol - Brazil Geotraverse Bathymetric Chart. Head Department of Navigation and Oceanography, Ministry of Defence and North Branch for Marine Geological Exploration ‘Sevmorgeologia’ - PGO ‘Sevmorgeologia’ of the USSR Ministry of Geology, USSR. (This chart was used to verify other information.)

10. Grindley, N.R., Fox, P.J. and Vogt, P.R., 1992. Morphology and Tectonics of the Mid-Atlantic Ridge (25°S to 27°30'S) from Sea Beam and Magnetic Data. Journal of Geophysical Research, 97 (B5), 6983-7010.

11. Batiza, R., Fox, P.J., Vogt, P.R., Cande, S.C., Grindley, N.R., Melson, W.G. and O'Hearn, T., 1989. Morphology, Abundance and Chemistry of Near-Ridge Seamounts in the vicinity of the Mid-Atlantic Ridge (26°S). Journal of Geology, 97 (2), 209-220.

12. Fox, P.J., Grindlay, N.R. and MacDonald, K.C., 1991. The Mid-Atlantic Ridge (31°S to 34°S): Temporal and Spatial Variations of Accretionary Processes. Marine Geophysical Researches, 13 (1), 1-20.

ANNEX L.14: GEBCO Sheet 5.14*

*MAJOR UPDATE NOTE: The bathymetry in the area of GEBCO sheet 5.14 west of 170°E (and west of 167°W north of 57.5°S) has been replaced by the revised bathymetry contained in GEBCO sheets G.08 and G.09.

GEBCO Sheet 5.14 was published in November 1981 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinators:	Robin K.H. Falconer (supported by the Bedford Institute of Oceanography, Dartmouth, Canada, and the New Zealand Oceanographic Institute, Wellington, New Zealand) and Marie Tharp, Lamont-Doherty Geological Observatory, New York, U.S.A.
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.14 (November 1981)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	72°00'S
Western Limit:	110°00'E
Northern Limit:	46°40'S
Eastern Limit:	160°00'W
Digitised by:	Bureau Gravimetrique International, Toulouse, France, in collaboration with Institut Geographique National, Paris, France, and the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0, 200, 500, 1000m and at 500m intervals thereafter down to 6000m.

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.14 CONTOURS

Contour Charts and Bathymetric Maps:

Johnson, G.L. and Vanney, J.R., 1980. GEBCO 5.18. This series.

Carter, L., 1980. New Zealand Region Bathymetry. 1:6,000,000 2nd. ed., New Zealand Oceanographic Institute misc. series 15.

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Ringis, J. and Hayes, D.E., 1972. Bathymetry of the Tasman Sea. Unpub. map, Lamont-Doherty Geology Observatory.

Mammerickx, J., Chase, T.E., Smith, S.M. and Taylor, I.L., 1974. Bathymetry of the South Pacific. Scripps Institution of Oceanography.

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Carter, L., Eade, J.V., Mitchell, J.S. and Rees, J., 1977. A morphologic guide to the continental oceanic crustal boundary around New Zealand. New Zealand Oceanographic Inst. Summary 13: 18 pp.

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Falconer, R.K.H. and Falconer, R.F., 1981 (in press). Seismicity, Fracture zones and poles of rotation of the Pacific-Antarctic and Indian-Antarctic plate boundaries. Third Antarctic Geology and Geophysics Symposium. University of Wisconsin Press.

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Hayes, D.E. and Talwani, M., 1972. Geophysical investigation of the Macquarie Ridge Complex. In: D.E. Hayes (Ed.) Antarctic Oceanology II. Antarctic Res. Ser. 19, Amer. Geophys. Union. 211-234.

Heezen, B.C., Tharp, M. and Bentley, C., 1972. Morphology of the Earth in the Antarctic and Subantarctic. In: Antarctic Map Folio Series, 15, Amer. Geographic Soc., 16 pp, 8 pl.

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Johnson, G.L., Vanney, J.R. and Hayes, D.E., 1981 (in press). The Antarctic Continental Shelf. Third Antarctic Geology and Geophysics Symposium University of Wisconsin Press.

Molnar, P., Atwater, T., Mammerickx, J. and Smith, S.M., 1977. Magnetic anomalies, bathymetry and the tectonic evolution of the south Pacific since the late Cretaceous. Geophys. Journ. Royal Astonom. Soc., 40: 383-420.

Vanney, J.R., Falconer, R.K.H. and Johnson, G.L., 1981. Geomorphology of the Ross Sea and adjacent oceanic provinces. Marine Geol., 41: 73-102.

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ANNEX L.15: GEBCO Sheet 5.15

GEBCO Sheet 5.15 was published in March 1982 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinators:	Jacqueline Mammerickx, Isabel L. Taylor, Scripps Institution of Oceanography, La Jolla, U.S.A.; and Steve Cande, Lamont-Doherty Geological Observatory, New York, U.S.A.
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.15 (March 1982)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	72°00'S
Western Limit:	160°00'W
Northern Limit:	46°40'S
Eastern Limit:	062°00'W
Digitised by:	Bureau Gravimetrique International, Toulouse, France, in collaboration with Institut Geographique National, Paris, France, and the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart but with an eastern limit of 78°W. The digitised contours for the region 62° to 78°W may be found in the digitised version of GEBCO Sheet 5.16.
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0, 200, 500, 1000m and at 500m intervals thereafter down to 5500m, plus additional contours at 100m intervals between 2800m and 5300m in the following areas: i) North of 52°S; 78° to 140°W ii) North of 60°S; 78° and 108°W iii) 58° to 65°S; 106° to 118°W

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.15 CONTOURS

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Molnar, P., Atwater, T., Mammerickx, J. and Smith, S.M., 1975, Magnetic Anomalies, Bathymetry and the Tectonic Evolution of the South Pacific since the Late Cretaceous. Geophys. J.R. Soc. 40: 383-420.

Cande, S.C., Herron, E.M. and Hall, B.R., 1981, The Early Cenozoic Tectonic History of the Southeast Pacific, Journal of Geophys. Research (in press).

The bathymetry east of longitude 78°W was taken from GEBCO sheet 5.16 and the bathymetry south of latitude 65°S was taken from GEBCO sheet 5.18.

ANNEX L.16: GEBCO Sheet 5.16*

*MAJOR UPDATE NOTE: Much of the bathymetry in the area of GEBCO sheet 5.16 has been replaced by the revised bathymetry contained in GEBCO sheets G.07 (Weddell Sea) and G.08. All that remains from the original sheet are the following areas:

a) 66°-72°S; 66°-78°W: b) 60°-66°S; 75°-78°W: c) 60°-64.5°S; 12°-15°W:
d) 56°-60°S; 20°-78°W: e) 50°-56°S; 12°-78°W: and f) 46°40'-50°S; 70°-78°W

GEBCO Sheet 5.16 was published in June 1981 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinators:	John La Brecque, Philip D. Rabinowitz and Carl Brenner, Lamont-Doherty Geological Observatory, New York, U.S.A.
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.16 (June 1981)
Projection: Mercator Scale:	1 to 10 million at the Equator
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	72°00'S
Western Limit:	078°00'W
Northern Limit:	45°00'S
Eastern Limit:	020°00'E (40°S for east of 5°W)
Digitised by:	Bureau Gravimetrique International, Toulouse, France, in collaboration with Institut Geographique National, Paris, France, and the British Oceanographic Data Centre
Geographic Area Digitised:	as for published chart, except for the area north of a line joining the points 78°W 46°40'S, 70°W 46°40'S, 70°W 50°S, 20°E 50°S. This area is covered by the digital data in GEBCO sheet 5.12.
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0, 200, 500, 1000m and at 500m intervals thereafter down to 8000m plus the following: i) 20, 40, 60, 80 and 100m on the continental shelf east of Argentina ii) 750, 1250 and 1750m on the Falkland Plateau and off the Continental Shelf east of Argentina iii) 3600, 3700, 3800, 3900 and 4100m west of Chile and north of 48°S iv) at 250m intervals from 250m to 4750m for the chart area south of 64°S and east of 55°W

Comments:	On the published chart there is an erroneous chain of seamounts in the area 65.5° to 67°S; 22.5° to 25.5°W sometimes referred to as the Islas Orcadas seamounts. These have been found to be non-existent and their contours have been removed from the digitised data set.

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.16 CONTOURS

Lamont-Doherty Geological Observatory, Columbia Univ. Palisades, New York, 10964, USA.
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 02543, USA.
Scripps Institution of Oceanography, La Jolla, California, 92093, USA.
Defense Mapping Agency, Sutland, Maryland, USA.
National Geophysical and Solar-Terrestrial Data Centre, Boulder, Colorado, 80302, USA.
University of Cape Town, Rondebosch 7700 Cape Town, South Africa.
Instituto Hidrografico de la Armada, Casilla 324, Valparaiso, Chile.
Servicio de Hidrografia Naval, Avenida Montes de Oca 2124, 1271 Buenos Aires, Argentina.
University of Birmingham, P.O. Box 363, Birmingham, UK.
Hydrographic Office, Ministry of Defence, Taunton, TA1 2DN, UK.

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Bergh, H.W., 1977. Mesozoic sea floor off Dronning Maud Land, Antarctica, Nature, 269, 686-687.

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Dalziel, I.W.D., 1974. Evolution of the margins of the Scotia Sea, Burk, C.A. and Drake, C.L., (Eds.) The Geology of Continental margins: New York, Springer-Verlag New York Inc., 567-579.

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ANNEX L.18: GEBCO Sheet 5.18*

*MAJOR UPDATE NOTE: The bathymetry in the area of GEBCO sheet 5.18 between 0°W and 66°W has been replaced by the revised bathymetry contained in GEBCO sheet G.07. The only bathymetry from sheet 5.18 that remains in the GEBCO Digital Atlas is that for the South Pacific region south of 72°S between 160°E and 66°W.

GEBCO Sheet 5.18 was published in August 1980 by the Canadian Hydrographic Service under the authority of the IHO and IOC.

Scientific Coordinators:	G. Leonard Johnson, Office of Naval Research, Arlington, U.S.A.; and Jean-Rene Vanney, Universite Pierre et Marie Curie, Paris, France
Cartography by:	Geoscience Mapping Unit, Canadian Hydrographic Service
Published Chart:	GEBCO SHEET 5.18 (August 1980)
Projection:	Polar Stereographic Scale: 1 to 6 million at 75°S
Ellipsoid:	International 1924 (Hayford)
Southern Limit:	90°00'S
Western Limit:	180°00'W
Northern Limit:	64°00'S
Eastern Limit:	180°00'E
Digitised by:	Bureau Gravimetrique International, Toulouse, France, in collaboration with Institut Geographique National, Paris, France, and the British Oceanographic Data Centre
Geographic Area Digitised:	the published chart was only digitised south of 72°S.
Contour Units:	bathymetric depth in corrected metres
Contours Present:	0, 200, 400, 500, 600m and at 200m intervals thereafter down to 4400m.

DATA SOURCES USED IN THE COMPILATION OF SHEET 5.18 CONTOURS

Scientific Literature:

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Falconer, R.K.H. and Falconer, R.F., 1979. Seismicity, fracture zones and poles of rotation of the Pacific-Antarctic and Indian-Antarctic plate boundaries. Third Antarctic Geology and Geophysics Symp. University of Wisconsin Press, in press.

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Hurley, D.E. and Krause, D.C., 1976. Hjort bathymetry. New Zealand Oceanographic Institute Chart, Oceanic Series, 1:1,000,000.

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ANNEX M: VERSION 2.0 OF THE GEBCO ONE MINUTE GRID

The GEBCO One Minute Grid was originally released in 2003 as part of the Centenary Edition of the GEBCO Digital Atlas (GDA). It is largely based on the bathymetric contours contained within the GDA with additional data used to help constrain the grid in some areas. You can find out more about the development of the grid from the documentation which accompanies the data set (gridhelp.pdf).

Version 2.0 of the GEBCO One Minute Grid was released in November 2008 and includes version 2.23 of the International Bathymetric Chart of the Arctic Ocean (IBCAO) and updated bathymetry for some shallow water areas around India and Pakistan, the Korean Peninsula and South Africa.

Included in version 2.0 of the GEBCO One Minute Grid

- Version 2.23 of the International Bathymetric Chart of the Arctic Ocean
- Shallow water bathymetry updates for:
  waters around India and Pakistan
  waters around the Korean Peninsula
  waters around South Africa
- Updates for some reported bug fixes in version 1.0 of the GEBCO One Minute Grid

VESRSION 2.23 OF THE INTERNATIONAL BATHYMETRIC CHART OF THE ARCTIC OCEAN (IBCAO)

Authors: Martin Jakobsson[1], Ron Macnab[2], Larry Mayer[3], Robert Anderson[4], Margo Edwards[5], Jörn Hatzky[6], Hans Werner Schenke[6] and Paul Johnson[5]
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[3]Center for Coastal and Ocean Mapping, University of New Hampshire, NH, USA
[4]SAIC-Science Applications International Cooperation, WA, USA
[5]Hawaii Institute of Geophysics and Planetology, University of Hawaii, Honolulu, HI, USA
[6]Alfred Wegener Institute, Brmerhaven, Germany

Data set limits: north of 64°N to 90°N; 180°W to 180°E

Citation: Jakobsson, M., Macnab, R., Mayer, M., Anderson, R., Edwards, M., Hatzky, J., Schenke, H-W., and Johnson, P., 2008, An improved bathymetric portrayal of the Arctic Ocean: Implications for ocean modeling and geological, geophysical and oceanographic analyses, v. 35, L07602, Geophysical Research Letters, doi:10.1029/2008GL033520

The IBCAO was first released in 2000. Since then there have been a number of multibeam surveys in the Arctic Ocean region which have significantly improved our knowledge of the shape of the seafloor in this region. The IBCAO team felt this warranted an update to the IBCAO data set and version 2.23 of the IBCAO was released in March 2008.

Further details about the IBCAO data set along with grids and maps for downloading can be found at: http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html.

SHALLOW WATER BATHYMETRY UPDATES

GEBCO has traditionally depicted the bathymetry of the deeper water areas of the world's oceans, i.e. at depths of 200 m and deeper. In order to more adequately represent the shape of the ocean floor in all areas, and to serve a wide range of users, the GEBCO community has recognised the importance of improving the GEBCO One Minute Grid in shallow water areas.

The bathymetry data held collectively by International Hydrographic Organization (IHO) Member States in the Electronic Navigation Chart (ENC) system was recognised as a valuable source of data which could be used to significantly improve the existing and future GEBCO grids in shallow water regions.

Extracting bathymetry data from ENCs

A software application was developed to simplify the extraction of data from ENC files (usage bands 2 and 3). This software package was supplied to IHO Member States on request. This work was co-ordinated by the International Hydrographic Bureau (IHB).

The software extracts data from ENC GEO object classes (SOUNDG, COALNE and DEPCNT) and META object classes (M_VDAT, M_SDAT and M_QUAL) into simple ASCII format files. Further information about object classes and attributes associated with them can be found in the IHO document: IHO Transfer Standard for Digital Hydrographic Data (S57).

Many Hydrographic Offices have already contributed shallow water bathymetry data. Data for three regions have so far been used to update the GEBCO One Minute Grid. This work is described below.

Updating the GEBCO One Minute Grid

Sounding point data extracted from ENCs for the areas around India and Pakistan, the Korean Peninsula and South Africa has been used to update the GEBCO One Minute Grid and have been released as part of version 2.0 of this data set.

Work on the incorporation of shallow water bathymetry data into the GEBCO One Minute Grid was carried out at the British Oceanographic Data Centre (BODC). For further information contact Pauline Weatherall (paw@bodc.ac.uk).

The general method used to update the grid in shallow water regions is described below. Further information about the data provided and the generation of the grid for each of these separate areas is given at the end of this document.

Data source – soundings extracted from ENCs

For each region, sounding points were provided from a number of overlapping ENC data sets. An attempt has been made to edit data from overlap regions. Only those ENC sounding points shallower than 300m were used in the gridding work.

The ENC data are to chart datum - no attempt has been made to adjust the data for the state of the tide.

Data source – original GEBCO One Minute Grid

The aim of this work is to update the existing GEBCO grid in shallow water regions, therefore the ENC sounding point data were combined with the original source data used to generate the GEBCO One Minute Grid, i.e. bathymetric contours from the GEBCO Digital Atlas, additional control used to constrain the grid; World Vector Shoreline and land elevation data from the Global Land One-km Base Elevation (GLOBE) project data set.

Harmonising the data sets

A Geographic Information System (GIS) was used to visualise the relationship between the original grid source data sets and the ENC sounding points. In some areas, it was necessary to edit the GEBCO bathymetric contours to harmonise the data sets. The ENC sounding points, GEBCO bathymetric contours, additional grid control data, coastline and land elevation data were then combined into one ASCII XYZ file.

Gridding work

The gridding work was done using routines from the Generic Mapping Tools (GMT) suite of software. The data were first filtered using the ‘blockmedian’ routine. The gridding was done using the ‘surface’ routine.

The grids were then checked for any errors or grid artefacts and the gridding process was repeated if necessary.

More detailed information about the generation of the grids for each area follows below.

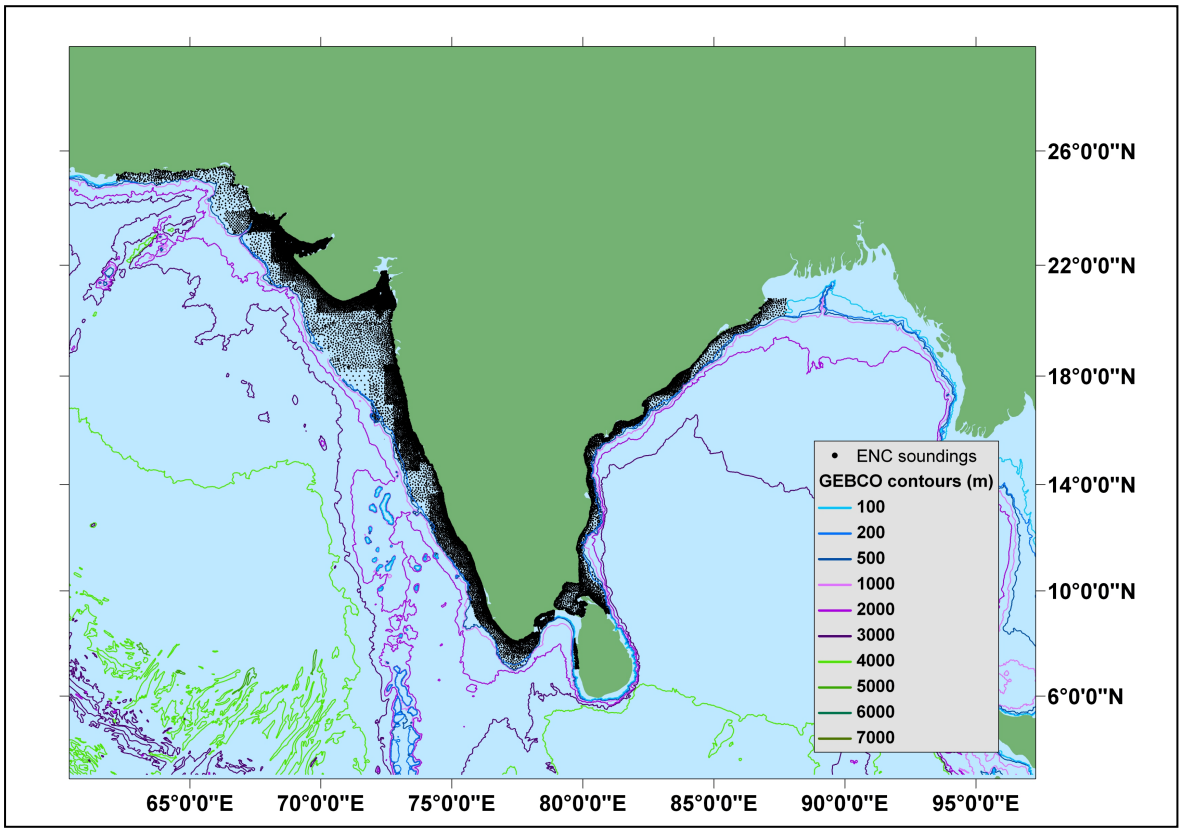
Please note that although the grid has been improved in shallow water regions the data set is not to be used for navigation or any purpose relating to safety at sea.

IMPROVING THE GEBCO ONE MINUTE GRID IN THE AREA AROUND INDIA AND PAKISTAN

Geographic area: Coastal regions shallower than 300m between 62° 12'E and 87°E
ENC data set provider: National Hydrographic Office, India

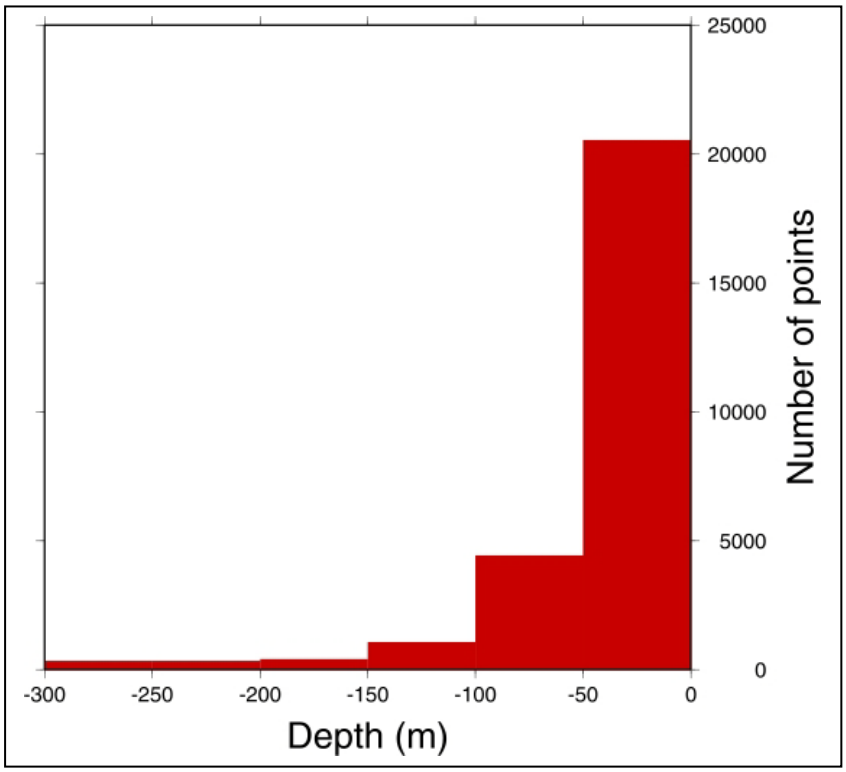
The data set supplied by the National Hydrographic Office, India consists of 44 separate ENC data files.

Only those ENC sounding points shallower than 300m were used in the gridding work, the resulting data file contains 27,113 points. The image below shows the coverage of the ENC sounding points used to generate the grid.



Distribution of ENC sounding points used in the gridding work

The histogram below shows the number of sounding points from the ENC data set per 50m depth interval used to update the GEBCO One Minute Grid.



A Geographic Information System (GIS) was used to visualise the relationship between the original grid source data – i.e. bathymetric contours from the GEBCO Digital Atlas and the ENC sounding points. In some areas, it was necessary to edit the GEBCO bathymetric contours to harmonise the data sets. The ENC sounding points, GEBCO bathymetric contours, additional grid control data, coastline and land elevation data were then combined into one ASCII XYZ file.

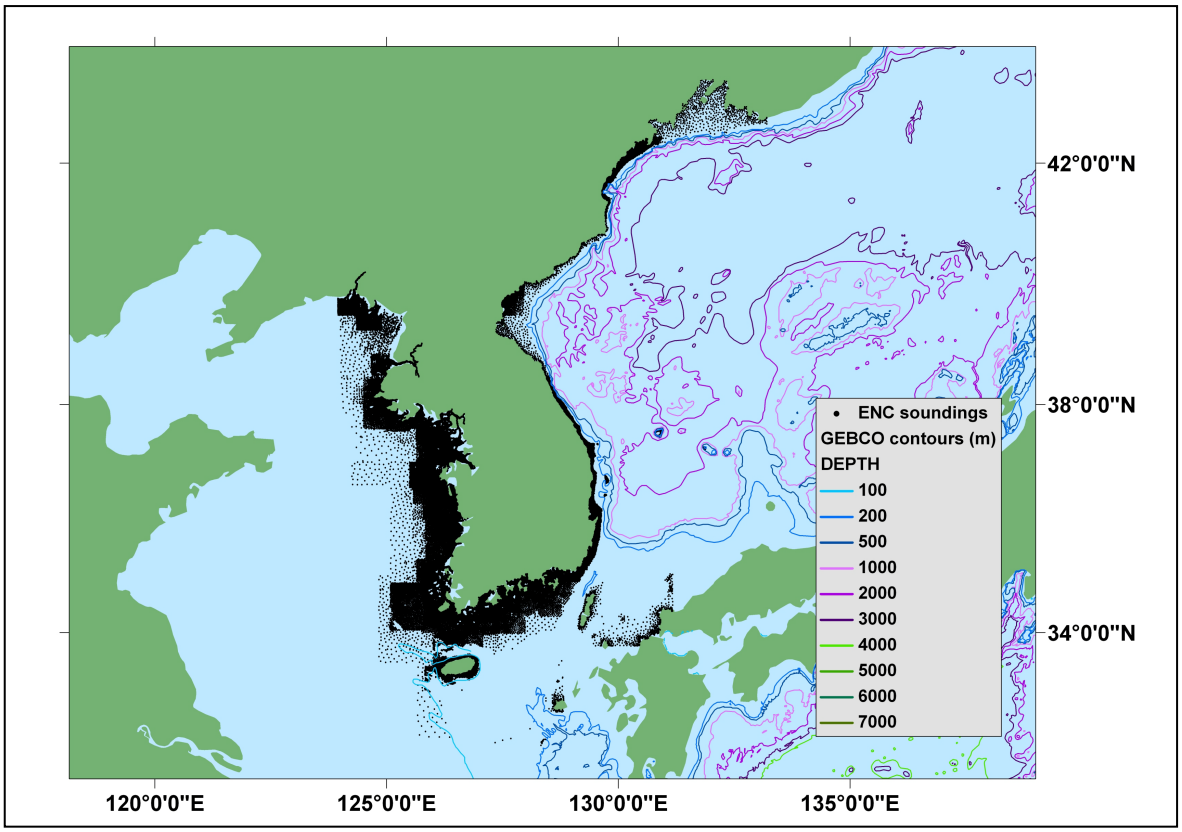
The gridding work was done using Generic Mapping Tools (GMT) software routines.

IMPROVING THE GEBCO ONE MINUTE GRID IN THE AREA AROUND THE KOREAN PENINSULA

Geographic area: coastal areas shallower than 300m between 123° 56'E and 132°E
Data provider: National Oceanographic Research Institute (NORI), Republic of Korea

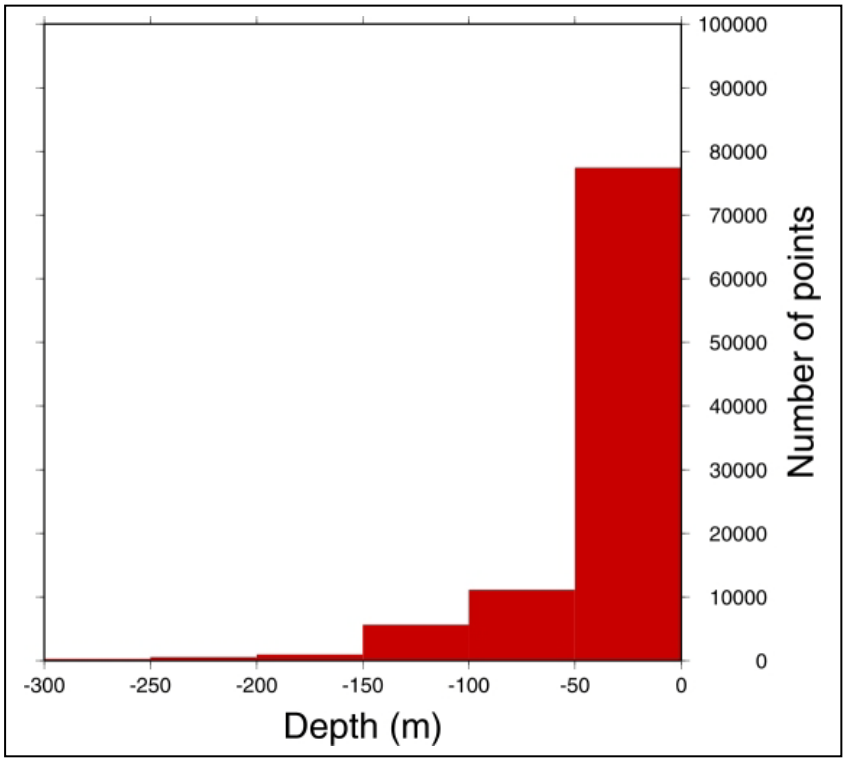
The data set supplied by NORI consists of bathymetric soundings, bathymetric contours, coastline data and quality of data information polygons. The bathymetric sounding point data set were used for the gridding work. The data are taken from 82 separate ENC data files.

Only those sounding points shallower than 300m have been included for the gridding work. The resulting data file used for gridding contains 96,061 points.



Distribution of ENC sounding points used in the gridding work

The histogram below shows the number of sounding points from the ENC data set per 50m depth interval used for gridding.



A Geographic Information System (GIS) was used to visualise the relationship between the original grid source data – i.e. bathymetric contours from the GEBCO Digital Atlas and the ENC sounding points. In some areas, it was necessary to edit the GEBCO bathymetric contours to harmonise the data sets. The ENC sounding points, GEBCO bathymetric contours, additional grid control data, coastline and land elevation data were then combined into one ASCII XYZ file.

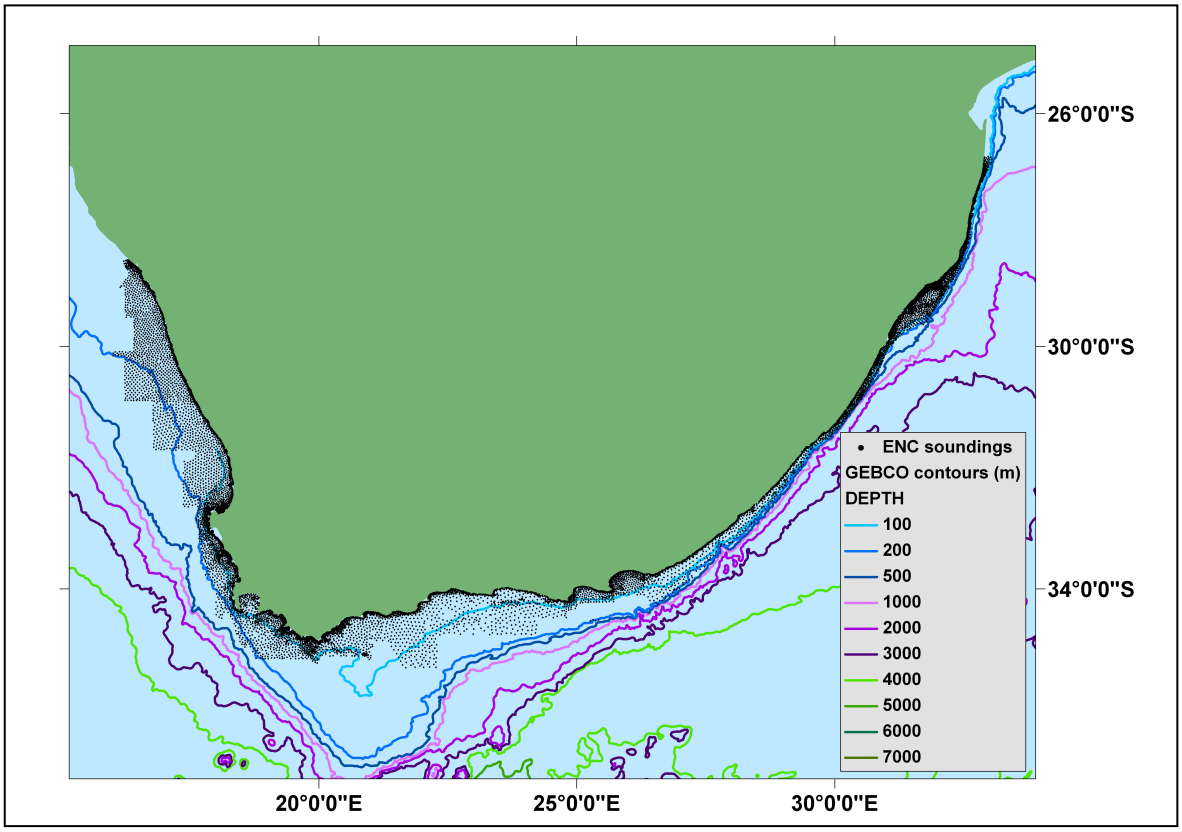
The gridding work was done using routines from the Generic Mapping Tools (GMT) system.

IMPROVING THE GEBCO ONE MINUTE GRID IN THE AREA AROUND SOUTH AFRICA

Geographic area: coastal areas shallower than 300m between 16° 20'E and 32° 54'E
Data provider: South African Hydrographic Office

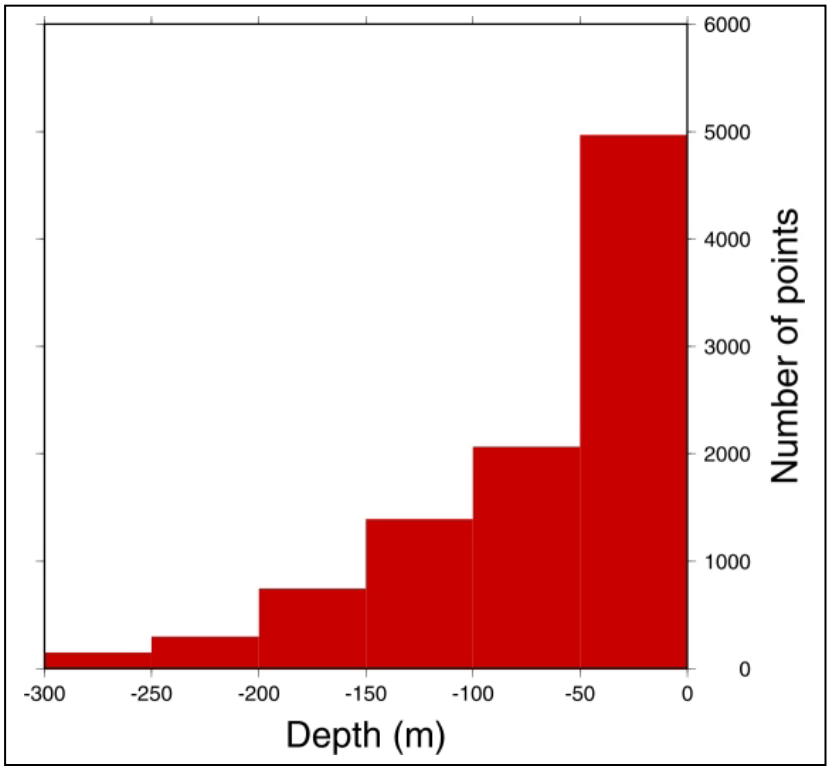
The data set supplied by the South African Hydrographic Office consists of bathymetric soundings, bathymetric contours, coastline data and quality of data information polygons. The bathymetric sounding point data set were used for the gridding work. The data are taken from 23 separate ENC data files.

Only those ENC sounding points shallower than 300m were used in the gridding work, the resulting data file contains 9,622 points. The image below shows the coverage of the ENC sounding points used to generate the grid.



Distribution of ENC sounding points used in the gridding work

The histogram below shows the number of sounding points from the ENC data set per 50m depth interval used for gridding.



A Geographic Information System (GIS) was used to visualise the relationship between the original grid source data – i.e. bathymetric contours from the GEBCO Digital Atlas and the ENC sounding points. In some areas, it was necessary to edit the GEBCO bathymetric contours to harmonise the data sets. The ENC sounding points, GEBCO bathymetric contours, additional grid control data, coastline and land elevation data were then combined into one ASCII XYZ file.

The gridding work was done using Generic Mapping Tools (GMT) routines.

UPDATES FOR REPORTED BUGS IN VERSION 1.0 OF THE GEBCO ONE MINUTE GRID

Version 2.0 of the GEBCO One Minute Grid includes updates for reported bugs in the Hudson Bay area and off the west coast of Africa.

A list of reported bugs in the GEBCO One Minute Grid can be found on the following web site: http://www.bodc.ac.uk/help_and_hints/errata/gebco.html

ANNEX N – GEBCO_2014 Grid

Contents

Preface

The General Bathymetric Chart of the Oceans (GEBCO) consists of an international group of experts who work on the development of a range of bathymetric data sets and data products, with the aim of providing the most authoritative, publicly available bathymetric data sets for the world's oceans.

GEBCO operates under the joint auspices of the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO.
This document provides information on GEBCO's latest gridded product, the GEBCO_2014 Grid.

Find out more about GEBCO from our web site — www.gebco.net

1. Introduction — The GEBCO_2014 Grid

The GEBCO_2014 Grid is a continuous terrain model for ocean and land with a spatial resolution of 30 arc seconds. It is an updated version of the GEBCO_08 Grid.
The GEBCO_08 Grid was first published in January 2009. The bathymetric portion of the grid was developed from a database of ship track soundings with interpolation between soundings guided by satellite-derived gravity data.

Since its initial release, the GEBCO community has been working on updating this data set. Where they improve on this 'base grid', data sets generated by other methods have been included.

Recognising the importance of local expertise when building a global bathymetric grid, GEBCO has been working with regional mapping groups to improve its global bathymetric model. This release of the grid benefits from collaborations with a number of regional groups. Further details can be found in the Annex at the end of this section and on our regional mapping web pages: www.gebco.net/regional_mapping/mapping_projects/

Details on the development of the grid are given below along with information on its update history.

For information on the data sets referenced in this document, please see the References and Links section and the Annex to this section below.

2. Grid development

The GEBCO grid, called 'GEBCO_08', was originally derived from v5.0 of the SRTM30_plus data set[3], released in 2008. This grid was produced by combining the published Smith and Sandwell global topographic grid between latitudes 80° N and 81° S (version 11.1, September, 2008) with a database of over 290 million bathymetric soundings.
Within the Smith and Sandwell global topographic grid, the predicted depths are based on version V16.1 of the Sandwell and Smith gravity anomaly from Geosat and ERS 1 satellite altimetry, created in March 2007.

The original GEBCO_08 Grid was developed as a collaborative effort by the following organisations

- The General Bathymetric Chart of the Oceans (GEBCO)
- International Hydrographic Bureau (IHB)
- The US National Geospatial-Intelligence Agency (NGA)
- The US National Oceanic and Atmospheric Administration (NOAA)
- The US Naval Oceanographic Office (NAVO)
- Scripps Institution of Oceanography (SIO)
- The UK Natural Environment Research Council (NERC)

Bathymetric sounding data sets and compilation grids of measured bathymetry from a number of sources were used to generate the base grid, including

- Bathymetric soundings from the GEODAS[10] data set maintained by the International Hydrographic Organization (IHO) Data Center for Digital Bathymetry (DCDB) at the US National Geophysical Data Center (NGDC).
- Bathymetric grids and data files from the marine geology and geophysics community, including contributions from the Lamont Doherty Earth Observatory (LDEO) Ridge Multibeam Synthesis Project, GEOMAR, National Science Foundation (NSF) Polar Programs, the School of Ocean and Earth Science and Technology (SOEST) at the University of Hawaii at Manoa and the WHOI/GLOBEC programme.
- Swath bathymetry grids from Scripps Institution of Oceanography multibeam cruises.
- Multibeam grids contributed by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC)[16].
- The US National Geophysical Data Center (NGDC) Coastal Relief Model[6].
- Multibeam grids from "Law of the Sea" work for areas around Alaska and the Arctic, the Marianas, Kingman Reef and Palmyra Atoll, the Western Atlantic Ocean and the Gulf of Mexico from the Center for Coastal and Ocean Mapping/Joint Hydrographic Center at the University of New Hampshire, USA[19].
- Bathymetric soundings contributed by the Institut Français de Recherche pour L'Exploitation de la Mer (IFREMER) from centre beam data from over 100 cruises.
- The Geological Survey of Ireland (GSI) provided a bathymetric grid for Irish designated waters based on multibeam surveys carried out between 2000 and 2006 as part of the Irish National Seabed Survey[12].
- In some shallow water areas (shallower than 300 m), bathymetry data have been provided by a number of the International Hydrographic Organization's (IHO) Member States. This work has been done through a project, coordinated by the International Hydrographic Bureau (IHB), to extract shallow water bathymetry data from Electronic Navigation Charts (ENCs).

Since the release of the first version of the GEBCO Grid in 2009, the data set has been updated with a number of bathymetric compilations as detailed in the data set update history section below.

2.1 **Procedures used to update the GEBCO base grid**

The inclusion of new data sets into the existing GEBCO base grid has been done with the aim of producing a seamless global terrain model.

For the majority of the updates supplied in the form of bathymetric grids or multibeam surveys, the 'remove-restore' procedure (Smith and Sandwell, 1997; Becker, Sandwell and Smith, 2009 and Hell and Jakobsson, 2011) has been used.

This is a two stage process of computing the difference between the new data and the existing grid and then gridding the difference and adding the difference back to the existing base grid. The aim is to achieve a smooth transition between the 'new' and 'old' data sets with the minimum of perturbation of the existing base data set.

For new data sets supplied in the form of isolated soundings a grid has been produced from the data points using an adjustable tension continuous curvature surface gridding algorithm, i.e. 'surface' from Generic Mapping Tools (GMT) (Smith and Wessel, 1990).

2.2 **Reporting bugs in the GEBCO Grid**

While every effort is made to produce an error free grid, some artefacts may still appear in the data set. Please see our errata web page for information on known bugs in the dataset If you find any anomalies in the grid then please report them via email (enquiries@bodc.ac.uk), giving the problem location, and we will investigate.

3. Land data

With the exception of polar regions, land data are based on the one km averages of topography derived from version 2.0 of the US Geological Survey SRTM3025 gridded digital elevation model data product, created with data from the US National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission.

For the Arctic region north of 64° N the GEBCO grid is based on the International Bathymetric Chart of the Arctic Ocean (IBCAO) v3[17]. This data set uses land data taken largely from the Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010)[5] data set. Over Greenland the approximately 2000 by 2000 m resolution Digital Elevation Model (DEM)[8] published by Ekholm (1996) is used.

For the Southern Ocean area, south of 60° S, land data are taken from Bedmap[29] data set as included in the International Bathymetric Chart of the Southern Ocean (IBCSO)[1].

4. GEBCO Source Identifier (SID) Grid

The GEBCO Grid is accompanied by a Source Identifier (SID) grid. This data set identifies which of the corresponding grid cells in the GEBCO Grid are based on bathymetric soundings or bathymetric depth values from grids and which cells contain predicted or interpolated depth values. Further information about the format and coding of the data set is given below.

4.1 GEBCO SID Grid coding

The table below details the coding of the GEBCO_2014 Source Identifier (SID) grid. It includes a description of the data source that the corresponding grid cell in the GEBCO_2014 Grid is based on.

SID file coding	Description
0	The grid value at this location has been developed from a database of ship track soundings with interpolation between soundings guided by satellite derived gravity data. At this location in the grid, the data value has been interpolated.
9999	The grid value at this location has been developed from a database of ship track soundings with interpolation between soundings guided by satellite derived gravity data. At this location, the grid cell has been constrained by a bathymetric sounding(s) data during the gridding process.
-8888	The grid value at this location has a positive value (+ve), i.e. is coded as land. Please note that for the Southern Ocean region (south of 60°S) based on the IBCSO, elevation values are based on the Bedmap2 data set and coded as 3500.

110	The grid value at this location is taken from the Caspian Sea grid, (see Annex N.1). This grid has been generated from a data set of soundings using a kriging gridding algorithm. SID grid cells that contain a sounding(s) from the Caspian Sea source data set are coded as '1100'.
120	The grid value at this location is taken from the Black Sea grid, (see Annex N.2). This grid has been generated from a data set of soundings using a kriging gridding algorithm. SID grid cells that contain a sounding(s) from the Black Sea source data set are coded as '1200'.
130	The grid value at this location is taken from the GEBCO_08 Grid. In this region, the GEBCO_08 Grid is based on the Weddell Sea grid, (seeAnnex A.3). This grid has been generated from a data set of bathymetric contours based largely on multibeam and single beam bathymetric surveys. SID grid cells that contain trackline control from the Weddell Sea source data set are coded as '1300'.
1100	The grid value at this location is taken from the Caspian Sea grid, (see Annex A.1). The grid cell at this location contains a sounding(s) from the Caspian Sea source data set. For the Caspian Sea grid, cells that do not contain a sounding(s) are coded as '110'.
1200	The grid value at this location is taken from the Black Sea grid, (see Annex A.2). The grid cell at this location contains a sounding(s) from the Black Sea source data set. For the Black Sea grid, cells that do not contain a sounding(s) are coded as '120'.
1300	The grid value at this location is taken from the GEBCO_08 Grid. In this area the GEBCO_08 Grid is based on the Weddell Sea grid, (see Annex A.3). This grid has been generated from a data set of bathymetric contours based largely on multibeam and single-beam bathymetric surveys. The grid cell at this location is 'crossed' by trackline control information, i.e. survey track or isolated sounding, from the Weddell Sea source data set. For the Weddell Sea grid, cells that do not contain trackline control are coded as '130'.
1400	The grid value at this location is taken from the Geoscience Australia grid 'Australian Bathymetry and Topography Grid, June 2009'.

1500	The grid value at this location is based on ENC soundings supplied by the East Asia Hydrographic Commission.
1550	The grid value at this location is based on ENC bathymetric contours supplied by the East Asia Hydrographic Commission.
1600	The grid value at this location is based on gridded data from the North American Great Lakes gridded data sets.
1700	The grid value at this location is based on gridded data from the Gulf of Cadiz gridded data set 'The quest for the Africa-Eurasia plate boundary west of the Strait of Gibraltar'.
1800	The grid value at this location is based on multibeam data from the 2004 cruise of HMS Scott.
1900	The grid value at this location is taken from the IBCAO V3 grid (www.ibcao.org) and is based on interpolation.
1910	The grid value at this location is based on multibeam data.
1920	The grid value at this location is based on single beam data in the IBCAO V3 or IBCSO V1 grids.
1940	The grid value at this location is taken from the IBCSO V1 grid and is based on depth data from digital bathymetric models.
1950	The grid value at this location is taken from the IBCAO V3 and is based on depth contours from digitised charts.
2000	The grid value at this location is based on Olex data.
2100	The grid value at this location is based on interpolation using an adjustable tension continuous curvature surface gridding algorithm 'surface' from GMT.
2200	The grid value at this location is based on data from the Lamont-Doherty Earth Observatory (LDEO) of Columbia University, Global Multi-Resolution Topography Synthesis.
2300	The grid value at this location is based on a gridded bathymetric data set for Irish designated waters, based on multibeam surveys, provided by the Geological Survey of Ireland. The gridded data set is included as part of the EMODnet Bathymetry grid (SID code 3800).
3100	The grid value at this location is taken from the IBCSO V1 grid and is based on

	data from nautical charts.
3200	The grid value at this location is taken from the IBCSO V1 grid and is based on steering points.
3300	The grid value at this location is taken from the IBCSO V1 grid and is based on interpolation.
3400	The grid value at this location is based on data from the GEBCO_08 Grid. In this region, the GEBCO_08 Grid is based on interpolation guided by satellite-derived gravity data.
3450	The grid value at this location is based on data from the GEBCO_08 Grid. At this location, the GEBCO_08 Grid is based on measured sounding data.
3500	The grid value at this location is taken from the IBCSO V1 grid and is based on data from the Bedmap2 data set
3600	The grid value at this location is taken from the IBCSO V1 grid and is based on other grids and data sets
3700	The grid value at this location is based on control contours used to help constrain the grid interpolation process using GMT's 'surface' gridding algorithm
3800	The grid value at this location is based on data from the EMODnet 2013 Grid.
3900	The grid value at this location is taken from the Baltic Sea Bathymetry Database grid.
4000	The grid value at this location is based on the GEBCO One Minute Grid.
4100	The grid value at this location is based on bathymetric contours from the Centenary Edition of the GEBCO Digital Atlas.
4200	The grid value at this location is based on bathymetric contours from the International Bathymetric Chart of the Mediterranean (IBCM).
4300	The grid value at this location is based on multibeam data from RRS Charles Darwin cruise CD118.
4400	The grid value at this location is based on ENC soundings provided by the Servicio Hidrográfico y Oceanográfico de la Armada de Chile.
4500	The grid value at this location is based on the Japanese Coast Guard grid and in

	this region the grid is based on multibeam data.
4550	The grid value at this location is based on the Japanese Coast Guard grid and in this region the grid is based on the J-EGG500 grid JODC-Expert Grid data for Geographic -500m.

5. Data set update history

The current version of the GEBCO grid is: 20141103.

The table below provides information on the updates included in the GEBCO_2014 Grid since its original release (as GEBCO_08) in 2009. Further information on these data sets can be found in the Annex at the end of this document.

Grid version number	Updated region	Annex	Grid release date
20091120	Arctic Ocean (north of 64° N) — International Bathymetric Chart of the Arctic Ocean (IBCAO). Please note that this data set has now been replaced by version 3 of the IBCAO and therefore information about the data set is not included in the Annex section.	—	December 2009
20100927	Caspian Sea — gridded data set provided by John K. Hall.	N.1	October 2010
20100927	Black Sea — gridded data set provided by John K. Hall.	N.2	October 2010
20100927	Weddell Sea — Bathymetric Chart of the Weddell Sea (BCWS), grid provided by the Alfred Wegener Institute for Polar and Marine Research (AWI) Please note that this data set has now been replaced by version 1 of the IBCSO, however, it is included as part of the IBCSO compilation in some regions.	N.3	October 2010
20141103	Southern Ocean (south of 60° S) — International Bathymetric Chart of the Southern Ocean (IBCSO) V1	N.4	November 2014
20141103	Arctic Ocean (north of 64°N) — International Bathymetric Chart of the Arctic Ocean (IBCAO) V3	N.5	November 2014
20141103	European Marine Observation and Data Network	N.6	November 2014

	(EMODnet), 2013 data set.		
20141103	Baltic Sea Bathymetry Database.	N.7	November 2014
20141103	Waters around Australia — Australian Bathymetry and Topography Grid, June 2009	N.8	November 2014
20141103	Bathymetry data for all ocean regions — From the Global Multi-Resolution Topography (GMRT) synthesis, provided by the Lamont-Doherty Earth Observatory at Columbia University.	N.9	November 2014
20141103	Japan Coast Guard Grid for the North Western Pacific Ocean region.	N.10	November 2014
20141103	South China Sea region — update based on sounding data extracted from Electronic Navigation Charts (ENC), provided by the East Asia Hydrographic Commission.	N.11	November 2014
20141103	North American Great Lakes — Bathymetric grids provided by the US National Oceanic and Atmospheric Administration (NOAA), National Geophysical Data Center (NGDC).	N.12	November 2014
20141103	North Atlantic Ocean, Gulf of Cadiz region — Bathymetric compilation produced under the European Science Foundation (ESF) EuroMargins SWIM project 'Earthquake and Tsunami hazards of active faults at the South West Iberian Margin: deep structure, high-resolution imaging and paleoseismic signature'.	N.13	November 2014
20141103	Indian Ocean, region off Sumatra — Bathymetric survey carried out by HMS Scott in 2005.	N.14	November 2014
20141103	Waters off the West Coast of Africa — update based on bathymetry data from Olex	N.15	November 2014
20141103	Northwest European Continental Shelf area — update based on bathymetry data from Olex.	N.16	November 2014
20141103	South Pacific Ocean, Coral Sea region — update to correct an error in the GEBCO grid due to the inclusion of an erroneous island ("Sandy Island")	N.17	November 2014

20141103	Waters off Chile, update based on ENC sounding data.	N.18	November 2014

6. Grid format

GEBCO's gridded data sets are made available in netCDF, in the form of both two-dimensional (2D) and one-dimensional (1D) arrays of signed 2-byte integers. In addition, the 2D gridded data set uses the NetCDF Climate and Forecast (CF) Metadata Convention (http://cfconventions.org/).

The 1D grid file format is aimed specifically for use with the GEBCO Digital Atlas software interface and GEBCO Grid Display software. Please notethat these software packageswill not work with the 2D grid format files but solely with the global 1D grid files.

6.1 2D CF-netCDF format

Within the 2D CF-netCDF file, the grid is stored as a two-dimensional array of 2-byte signed integer values of elevation in metres, with negative values for bathymetric depths and positive values for topographic heights.
The complete data set gives global coverage, spanning 89° 59' 45"N, 179° 59' 45"W to 89° 59' 45"S, 179° 59' 45"E on a 30 arc-second grid. It consists of 21,600 rows x 43,200 columns, giving 933,120,000 data points. The netCDF storage is arranged as contiguous latitudinal bands. The data values are pixel-centre registered i.e. they refer to elevations at the centre of grid cells.

The data file includes header information which conforms to the NetCDF Climate and Forecast (CF) Metadata Convention (http://cfconventions.org/).

Please note that 2D grid format files will not work with either the GEBCO Digital Atlas software interface or the GEBCO Grid Display software package — these packages are designed to use the 1D version of GEBCO's grids. See the software packages and GEBCO's grids section below for further details on how the data may be viewed and accessed.

6.2 1D netCDF format

Within the 1D netCDF file, the grid is stored as a one-dimensional array of 2-byte signed integer values of elevation in metres, with negative values for bathymetric depths and positive values for topographic heights.

The complete data set gives global coverage. The grid consists of 21,600 rows x 43,200 columns, resulting in 933,120,000 data points. The data start at the Northwest corner of the file and are arranged in latitudinal bands of 360 degrees x 120 points per degree = 43,200 values. The data range eastward from 179° 59' 45" W to 179° 59' 45" E. Thus, the first band contains 43,200 values for 89° 59' 45" N, then followed by a band of 43,200 values at 89° 59' 15" N and so on at 30 arc second latitude intervals down to 89° 59' 45" S. The data values are pixel centre registered i.e. they refer to elevations at the centre of grid cells.
This grid file format is suitable for use with the GEBCO Digital Atlas Software Interface and GEBCO Grid display software and packages such as Generic Mapping Tools (GMT).
Please note that for ease of import into Esri ArcGIS Desktop software packages it is suggested that the 2D versions of GEBCO's grids are used. However, through the GridViewer and GDA software interfaces the data can be exported in an ASCII form suitable

for conversion to an Esri raster. See the software packages and GEBCO's grids section below for further details on how the data may be viewed and accessed.

7. Software packages and GEBCO's grids

GEBCO's grids are made available as either two-dimensional (2D) or one-dimensional (1D) arrays of 2-byte signed integers, see the grid format section above for further details. Below are just some of the software packages that can be used to view and work with the data sets.

7.1 Generic Mapping Tools (GMT)

Both GEBCO's 1D and 2D grids can be used with the GMT software system (http://gmt.soest.hawaii.edu/). GMT is an open source collection of around 65 tools for manipulating geographic and Cartesian data sets (including filtering, trend fitting, gridding, projecting, etc.) and producing image files from the data sets.

7.2 Esri ArcGIS Desktop software packages

For use of GEBCO's grids in Esri ArcGIS Desktop packages, such as ArcMap, it is possible to import the data in two ways.
1. For GEBCO's grids in 2D form it is suggested that they are imported as a 'netCDF raster layer'. The 'make netCDF raster layer' routine can be found in the Multidimension toolbox in ArcToolbox. See Esri's web site for further details — http://resources.arcgis.com/en/home/

2. For GEBCO's grids in 1D form you can use the GridViewer software interface (http://www.gebco.net/data_and_products/grid_display_software/) to export the data in Esri ASCII raster format. See the accompanying software documentation for further details. Data in this form can be converted to an Esri raster using the ArcToolbox routine 'ASCII to Raster' from the Conversion Tools toolbox.

8. GEBCO's grids and vertical datum

GEBCO's global elevation models are generated by the assimilation of heterogeneous data types, assuming all of them to be referred to mean sea level. However, in some shallow water areas, the grids include data from sources having a vertical datum other than mean sea level. We are working to understand how best to fully assimilate these data.

9. Data set attribution

If the data sets are used in a presentation or publication then we ask that you acknowledge the source. This should be of the form (including the appropriate version number)

For the GEBCO_2014 Grid:

> 'The GEBCO_2014 Grid, version 20141103, http://www.gebco.net'.

For the GEBCO_2014 SID Grid:

> 'The GEBCO_2014 SID Grid, version 20141103, http://www.gebco.net'.

The version number of the grid is given in the header information within the grid file.

10. Terms of use

Data within the GEBCO_2014 Grid are subject to copyright and database right restrictions. Reproduction of the gridded bathymetry data in derivative form for scientific research, environmental conservation, education or other non-commercial purposes is authorised without prior permission, providing the source material is properly credited.

The production of these gridded data sets is the result of an international collaboration between numerous scientists and hydrographers who have devoted much of their time and effort, often on a voluntary basis. This work was stimulated by a wish to create an authoritative, high quality bathymetry of the world's oceans for the benefit of all. Therefore, should you wish to pass on the data to third parties or use the data for commercial purposes, we ask that you contact us first.

In the first instance, please contact the British Oceanographic Data Centre (BODC) enquiries@bodc.ac.uk . Include a clear statement of the purpose for which the material will be used and the manner in which it will be reproduced.

In the case of commercial activities, a contribution may be requested for the further improvement of GEBCO's data sets.

11. Disclaimer

The GEBCO_2014 Grid is not to be used for Navigation or for any other purpose relating to safety at sea.

Information in the GEBCO_2014 Grid has been obtained from sources believed to be reliable but its accuracy and completeness cannot be guaranteed. While every effort has been made to ensure its reliability within the limits of present knowledge, no responsibility can be accepted by those involved in its compilation or publication for any consequential loss or damage arising from its use.

The GEBCO_2014 Grid is essentially a deep ocean product and does not include detailed bathymetry for shallow shelf waters. Even to the present day, most areas of the world's oceans have not been fully surveyed and, for the most part, bathymetric mapping is an interpretation based on random tracklines of data from many different sources. The quality and coverage of data from these sources is highly variable. Although the GEBCO_2014 Grid is presented at 30 arc second intervals of latitude and longitude, this does not imply that knowledge is available on sea floor depth at this resolution — the depth in most 30 arc second squares of the world's oceans has yet to be measured.

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Data sets included in the GEBCO_2014 Grid

The following is a list of the data sets used to update the original GEBCO_08 base grid, upon which the GEBCO_2014 Grid is based.

1. The Caspian Sea
2. The Black Sea
3. Weddell Sea Grid
4. International Bathymetric Chart of the Southern Ocean (IBCSO) v1
5. International Bathymetric Chart of the Arctic Ocean (IBCAO) v3
6. European Marine Observation and Data Network (EMODnet) Bathymetry 2013 data set
7. Baltic Sea Bathymetry Database
8. Australian Bathymetry and Topography Grid, June 2009
9. Global Multi-Resolution Topography (GMRT) Synthesis
10. Japan Coast Guard Grid for the North Western Pacific Ocean region
11. Bathymetry of the South China Sea Region
12. Bathymetry of the North American Great Lakes
13. North Atlantic Ocean, Gulf of Cadiz region
14. Indian Ocean region off Sumatra
15. Waters off the west coast of Africa
16. Northwest European Continental Shelf region

17. South Pacific Ocean, Coral Sea region
18. Waters off Chile

Annex N.1

The Caspian Sea

Included in — version 20100927 of the GEBCO_08 Grid, released in October 2010

Data set coverage — 46° 40' E - 54° 2' E; 36° 31' N - 47° N

Data set provider — Dr. John K. Hall, Geological Survey of Israel (retired)

Information on the data set is given below and further details can be found in — Bathymetric compilations of the seas around Israel I: The Caspian and Black Seas, J.K. Hall, Geological Survey of Israel, Current Research, Vol. 13, December 2002.

Data set information
The grid was generated from over 280,000 bathymetric soundings and points digitised from bathymetric contours, taken from 107 Russian hydrographic charts, on a Mercator projection relative to the Pulkovo 1942 datum.

The digitised soundings and contour data were converted from Mercator projection co-ordinates to x,y,z values on a Universal Transverse Mercator (UTM) projection on the WGS 84 datum using Global Mapper software.

The data, in UTM co-ordinates, were then gridded using a kriging algorithm from Golden Software Inc's Surfer software package using 100 m interval grid spacing.
The 100 m interval UTM grid was converted to geographic co-ordinates, with grid intervals of three arc seconds. Due to the Caspian Sea's lower sea level stand, 28 m was added to the depths in the grid, using Global Mapper software. The data set was supplied to GEBCO at this resolution.

The grid was sampled to 30 arc second intervals using 'grdsample' from Generic Mapping Tools (GMT).

Quality control checks were carried out on the data set, looking for artefacts in the gridded data. This was done by comparing the gridded data set with the source sounding and contour data. Any artefacts noted in the grid were removed.

The Caspian Sea grid was then incorporated into the GEBCO_08 Grid. This was achieved by firstly extracting grid points (largely land elevation) from the GEBCO_08 Grid that fell outside the geographic coverage of the Caspian Sea grid. These data were converted to ASCII x,y,z values. An ASCII x,y,z file of data values was created from the Caspian Sea grid. The data sets were combined and then gridded at 30 arc second intervals using 'Surface' (a minimum tension surface gridding algorithm) from GMT.

Annex N.2

The Black Sea

Included in — version 20100927 of the GEBCO_08 Grid, released in October 2010

Data set coverage — 26° E - 41° 46' E; 40° N - 47° 15'N

Data set provider — Dr. John K. Hall, Geological Survey of Israel (retired)

Information on the data set is given below and further details can be found in — Bathymetric compilations of the seas around Israel I: The Caspian and Black Seas, J.K. Hall, Geological Survey of Israel, Current Research, Vol. 13, December 2002.

Data set information

The grid was generated from over 196,400 bathymetric soundings digitised from Russian hydrographic charts, on a Mercator projection, relative to the WGS 72 and Pulkovo 1942 datums.

The data were gridded using a kriging algorithm from Golden Software Inc's Surfer software package. The gridded was converted to geographic co-ordinates (relative to WGS 84) and the data set was supplied to GEBCO at 15 arc second grid intervals.
The Black Sea grid was sampled to 30 arc second intervals using 'grdsample' from Generic Mapping Tools (GMT).
Quality control checks were carried out on the data set, looking for artefacts in the gridded data. This was done by comparing the gridded data set with the source sounding data. Any artefacts noted in the grid were removed.

The Black Sea grid was then incorporated into the GEBCO_08 Grid. This was achieved by firstly extracting grid points (largely land elevation) from the GEBCO_08 Grid that fell outside the geographic coverage of the Black Sea grid. These data were converted to ASCII x,y,z values. An ASCII x,y,z file of data values was created from the Black Sea grid and the data sets were combined and then gridded at 30 arc second intervals using 'Surface' (a minimum tension surface gridding algorithm) from GMT.

Annex A.3

The Weddell Sea - Bathymetric Chart of the Weddell Sea (BCWS)

Included in — version 20100927 of the GEBCO_08 Grid, released in October 2010

Data set coverage — 60° S to 66° S; 75° W to 15° W, 66° S to 79° S; 65° W to 2° E

Data set provider — Alfred Wegener Institute for Polar and Marine Research (AWI), http://www.awi.de

Data source and gridding method

The bathymetric grid was generated at AWI from the contours of the Bathymetric Chart of the Weddell Sea (BCWS). Further information about the BCWS is given below.
Bathymetric Chart of the Weddell Sea (BCWS)

The BCWS is a 1:1,000,000 map series plus a 1:3,000,000 master sheet based on compilations of bathymetric data in the Weddell Sea. This data set consists of bathymetric contour lines, generally at interval of 100m, but at 50m in the southern Weddell Sea.

Chief Editor — Dr. Hans Werner Schenke (AWI)

Publication dates — 1998-2001

Data set Digital Object Identifier (DOI) — doi:10.1594/PANGAEA.708081

Further information about the BCWS is given on AWI's web site.

Grid preparation

The bathymetric contour data from the BCWS were gridded in Mercator projection co-ordinates. Firstly, a Triangulated Irregular Network (TIN) grid was created from the contour lines using the Douglas-Peucker algorithm.

The TIN was converted to a grid with a regular cell spacing using Natural Neighbours interpolation with a cell size of 250m. The grid was then projected from Mercator to geographic coordinates with a cell size of 30 arc-seconds.

Annex N.4

International Bathymetric Chart of the Southern Ocean (IBCSO) version 1

Included in — version 20141103 of the GEBCO_2013 Grid, released in June 2013

Data set coverage — 60° S to 90° S; 180° W to 180° E

Data set provided by — Dipl.-Ing. Jan Erik Arndt, Alfred Wegener Institute, Bremerhaven, Germany, on behalf of the IBCSO team

Data set citation — Arndt, J.E., H. W. Schenke, M. Jakobsson, F. Nitsche, G. Buys, B. Goleby, M. Rebesco, F. Bohoyo, J.K. Hong, J. Black, R. Greku, G. Udintsev, F. Barrios, W. Reynoso-Peralta, T. Morishita, R. Wigley,The International Bathymetric Chart of the Southern Ocean (IBCSO) Version 1.0 - A new bathymetric compilation covering circum-Antarctic waters, Geophysical Research Letters, doi: 10.1002/grl.50413

Link to data source — www.ibcso.org

Data set information

The IBCSO is terrain model for the Southern Ocean area south of 60°S. It has been developed from a database of multibeam and single beam echo sounder data points — digitised soundings from nautical charts and regional bathymetric compilations. The data have been contributed by more than 30 institutions from 15 countries. Land and ice shelf regions are based on the Bedmap2 data sets.

Using the Bedmap2 data sets, the IBCSO grid is made available with a choice for land/ice shelf areas of either 'surface elevation', giving the surface elevation including ice cover, or 'bedrock', giving the surface elevation without ice cover. The data set is available at 500m grid intervals in Polar Stereographic projection units and also at one arc-minute grid intervals in geographic latitude and longitude co-ordinates.

Further information about the development of the data set can be found on the IBCSO web site — www.ibcso.org . Further information about Bedmap2 can be found on their web site — www.antarctica.ac.uk//bas_research/our_research/az/bedmap2/

For consistency with the Arctic region, the 'surface elevation' version of the IBCSO grid was used to update the GEBCO grid.

The one arc minute interval version of the IBCSO grid was sampled to 30 arc seconds using GMT's grdsample software routine. The data were edge matched with the existing GEBCO grid at 60° S using a feather blending routine, part of the Global Mapper v11.01 software package.

Annex N.5

International Bathymetric Chart of the Arctic Ocean (IBCAO) version 3

Included in — version 20141103 of the GEBCO_2013 Grid, released in June 2013

Data set coverage — 90° N to 64° N; 180° W to 180° E

Data set provided by — Prof. Martin Jakobsson, Stockholm University, Sweden, on behalf of the IBCAO team

Citation — Jakobsson, M., L. A. Mayer, B. Coakley, J. A. Dowdeswell, S. Forbes, B. Fridman, H. Hodnesdal, R. Noormets, R. Pedersen, M. Rebesco, H.-W. Schenke, Y. Zarayskaya A, D. Accettella, A. Armstrong, R. M. Anderson, P. Bienhoff, A. Camerlenghi, I. Church, M. Edwards, J. V. Gardner, J. K. Hall, B. Hell, O. B. Hestvik, Y. Kristoffersen, C. Marcussen, R. Mohammad, D. Mosher, S. V. Nghiem, M. T. Pedrosa, P. G. Travaglini, and P. Weatherall, The International Bathymetric Chart of the Arctic Ocean (IBCAO) Version 3.0, Geophysical Research Letters, doi: 10.1029/2012GL052219.

Link to data source — www.ibcao.org

Data set information

This version of the IBCAO represents the largest improvement in the data set since its release in 1999. It includes new data sets collected by the circum-Arctic nations, opportunistic data collected from fishing vessels and data acquired from US Navy submarines and research ships of various nations. The grid has been developed on 500 metre spacing and built using an improved gridding algorithm.

The IBCAO grid was edge matched with the existing GEBCO grid at 64° N using a feather blending routine, part of the Global Mapper v11.01 software package.

Annex N.6

European Marine Observation and Data Network (EMODnet) Bathymetry 2013 data set

Included in — version 20141103 of the GEBCO_2014 Grid, released in November 2014

Data set coverage — 63° N to 30° N; 34° W to 37° E

Data set provided by — EMODnet bathymetry team

Link to data source — www.emodnet-hydrography.eu

Data set information

EMODnet is a project, funded by the European Commission, to bring together marine data into interoperable, continuous and publicly available data sets for complete maritime basins in European waters.

As part of this project, the EMODnet bathymetry portal provides bathymetry data in the form of Digital Terrain Models (DTM) for selected maritime basins. The DTMs have been produced from collated bathymetric data sets integrated into a central DTM. There are 'holes' in the central DTM in regions where high resolution data sets are not available. Through a collaboration between GEBCO and the EMODnet bathymetry team, the 2013 version of the EMODnet grid has been incorporated into the GEBCO global grid using the 'remove-restore' procedure. This has resulted in a continuous grid with gaps filled by the existing GEBCO grid.

This combined grid has been included in GEBCO_2014 and forms the basis of future EMODnet bathymetric grid development work.

It is planned to continue the GEBCO and EMODnet collaboration work for future development of these data sets.

Annex N.7

Baltic Sea Bathymetry Database (BSBD)

Included in — version 20141103 of the GEBCO_2014 Grid, released in November 2014

Data set coverage — Baltic Sea region 66° N to 53° N 41'; 7° 45' E to 30° E

Data set provided by — BSBD team

Attribution — Baltic Sea Hydrographic Commission, 2013, Baltic Sea Bathymetry Database version 0.9.3. Downloaded from http://data.bshc.pro/

Link to data source — http://data.bshc.pro

Data set information

The Baltic Sea Bathymetry Database is the result of an effort to generate and make available a bathymetric grid for the Baltic Sea region using data from Baltic Sea countries' national hydrographic offices under the umbrella of the Baltic Sea Hydrographic Commission.

The data set was sampled to the same grid size interval as the GEBCO grid and then the 'remove-restore' procedure was used to include the grid into the GEBCO global grid.

Annex N.8

Australian Bathymetry and Topography Grid, June 2009

Included in — version 20141103 of the GEBCO_2014 Grid, released in November 2014

Data set coverage — 8° 30' S to 50° S; 105° E to 163° E

Data set provided by— Geoscience Australia

Data set identifier — Australia New Zealand Land Information Council (ANZLIC) unique identifier — ANZCW0703013116

Data set information

The bathymetric portion of the grid has been developed from a number of data sources, including

- Multibeam data
- Fairsheets (1:250,000 Series)
- Laser Airborne Depth Sounder (LADS) data
- ETOPO2v2g bathymetric grid

The sections of the grid based on Multibeam, Fairsheets and LADS data sets, mainly in near shore regions, have been used to update the GEBCO grid.
The data have been included into the GEBCO grid using the remove-restore procedure.

Annex N.9

Global Multi-Resolution Topography (GMRT) synthesis

Included in — version 20141103 of the GEBCO_2014 Grid, released in November 2014

Data set coverage — The GMRT synthesis contributes data in all ocean regions, the grid cells based on this data set are identified in the GEBCO Source Identifier Grid
Data set provided by — The Lamont-Doherty Earth Observatory (LDEO) of Columbia University

Link to data source — http://www.marine-geo.org/portals/gmrt/

Data set information

The LDEO GMRT synthesis makes use of sonar data collected by scientists and institutions worldwide, merging them into a single continuously updated compilation of high resolution seafloor topography. The synthesis began in 1992 as the Ridge Multibeam Synthesis (RMBS), was expanded to include multibeam bathymetry data from the Southern Ocean and now includes other bathymetry from throughout the global and coastal oceans.
LDEO have provided over 9,600 data tiles from their GMRT tile set (400 m resolution) for updating GEBCO's grid.

The data from the GMRT tile set has been included into the GEBCO grid using the remove-restore procedure.

Annex N.10

Japan Coast Guard Grid for the North Western Pacific Ocean region

Included in — version 20141103 of the GEBCO_2014 Grid, released in November 2014

Data set coverage — North Western Pacific Ocean area: 17°N - 43°N; 126°E - 160°E

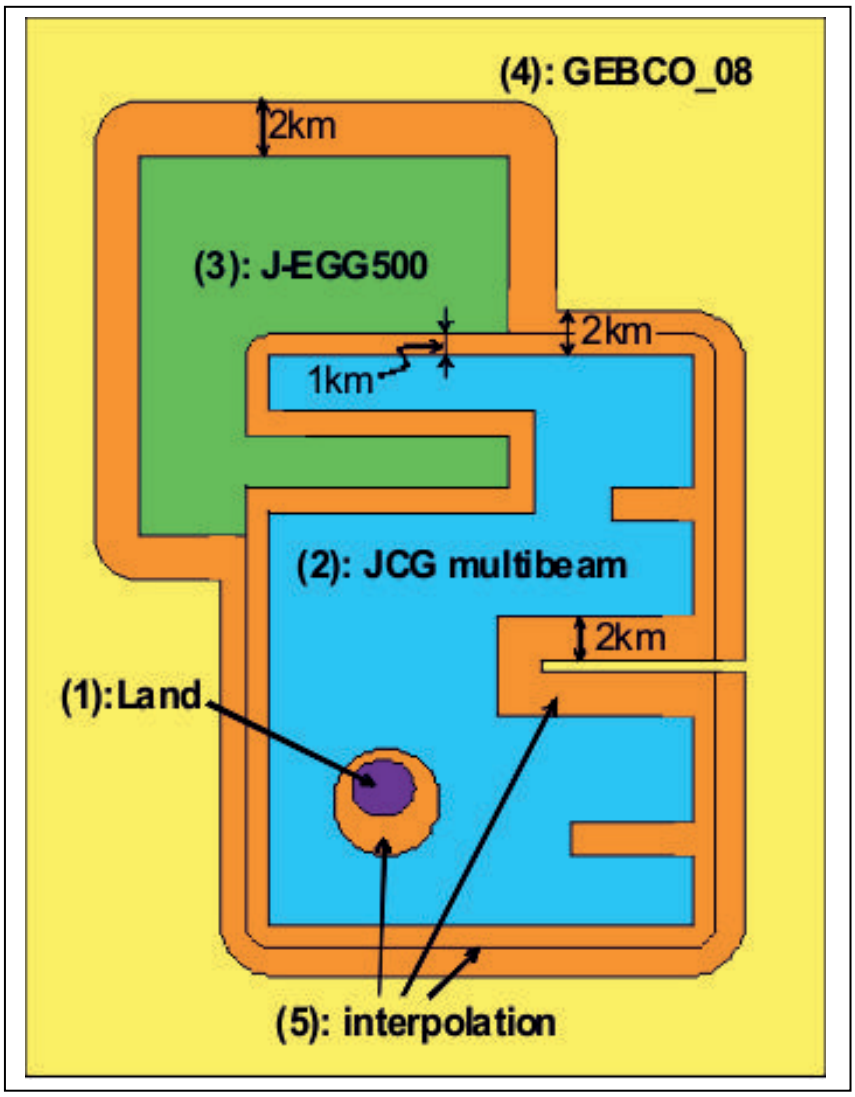
Data set provided by — Japan Oceanographic Data Center (JODC) of the Japan Coast Guard

Data set information

The grid for this area was originally developed at 9 arc-second intervals and based on the following source data
(1) Land data
(2) Multibeam data from the Japan Coast Guard

(3) A pre-prepared 500m interval grid based on measured sounding data: J-EGG500 grid JODC-Expert Grid data for Geographic -500mwww.jodc.go.jp/data_set/jodc/jegg_intro.html
(4) GEBCO_08

The gridded data set for the area was developed by combining the above data sources using the 'surface' gridding algorithm from Generic Mapping Tools (GMT). The areas where no multibeam data exists were filled with the J-EGG500 data (3) or with GEBCO_08 grid data (4) for the areas outside of the coverage of (3).



To avoid 'steps' between these data sets during the gridding process, 'buffering zones' were created around data sets (2) and (3). The buffer zone width was 1 km for the contact between (2) and (3), and 2 km for the contacts between (2) and (4) or between (3) and (4). The values in the 'buffering zones' are interpolated, based on values from the surrounding gridded data sets. In addition, the relatively small data gaps between land values and multibeam data or within the area based on multibeam data were interpolated from nearby data.

The final grid was generated by sampling to 30 arc seconds using 'grdsample' from Generic Mapping Tools.

The data set has been included into the GEBCO grid using the remove-restore procedure.

Annex N.11

Bathymetry of the South China Sea region

Included in — version 20141103 of the GEBCO_2014 Grid

Data set coverage — 101° E - 122° E; 5° S - 25° N

Data set provided by — The East Asia Hydrographic Commission

Data set information

Data extracted from Electronic Navigation Charts (ENCs) has been provided by the East Asia Hydrographic Commission for part of the South China Sea region to help update the GEBCO_08 Grid. This is as part of an initiative to help improve GEBCO's grids in shallower water regions, bathymetry.

Over 12,200 soundings were provided with over 8,570 in waters of a depth of 200 m or shallower. The data set also contains bathymetric contours.

Sounding point data and data from some of the bathymetric contours in the depth region of 200 m and shallower were used to update the GEBCO grid. These data were combined with data extracted from the GEBCO grid (in regions deeper than 200 m) and gridded using an adjustable tension continuous curvature surface gridding algorithm, i.e. 'surface' from Generic Mapping Tools (GMT).

Annex N.12

Bathymetry of the North American Great Lakes

Included in — version 20141103 of the GEBCO_2014 Grid

Data set coverage — 50° N - 40° 30' N; 93° W - 76° W

Link to data source — http://www.ngdc.noaa.gov/mgg/greatlakes/

Data set information

The bathymetry data for the North American Great Lakes are made available as part of program managed by NGDC and rely on the cooperation of NOAA/Great Lakes Environmental Research Laboratory, NOAA/National Ocean Service, the Canadian Hydrographic Service, other agencies and academic laboratories
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The gridded data files were downloaded from the US NGDC's web site (from the above link) with the 'Mean Sea Level' export option selected.

The data were included into the GEBCO grid using an adjustable tension continuous curvature surface gridding algorithm, i.e. 'surface' from Generic Mapping Tools (GMT).

Annex N.13

North Atlantic Ocean, Gulf of Cadiz region — SWIM project "Earthquake and Tsunami hazards of active faults at the South West Iberian Margin: deep structure, high-resolution imaging and paleoseismic signature"

Included in — version 20141103 of the GEBCO_2014 Grid

Data set coverage — 38° 36' N - 34° N; 13° 30' W - 5° 5' W

Data set citation — The quest for the Africa-Eurasia plate boundary west of the Strait of Gibraltar: Zitellini, N., Gràcia, E., Matias, L., Terrinha, P., Abreu, M.A., DeAlteriis, G., Henriet, J.P., Dañobeitia, J.J., Masson, D.G., Mulder, T., Ramella, R., Somoza, L. and Diez, S. (2009). Earth and Planetary Science Letters, 280, (1-4), 13-50. (doi:10.1016/j.epsl.2008.12.005)

Data set information

The grid was developed for a study into the missing link in the plate boundary between Eurasia and Africa in the central Atlantic — carried out under the European Science Foundation (ESF) EuroMargins SWIM project.

The data set was compiled from 19 bathymetric surveys carried out between 2000 and 2006 by teams belonging to 14 research institutions from seven European countries.
The data were included into the GEBCO grid using the remove-restore procedure.

Annex N.14

Indian Ocean region off Sumatra

Included in — version 20141103 of the GEBCO_2014 Grid

Data set coverage — 7° N - 1° 30' N; 92° E - 96° E

Data set acknowledgement — Timothy J. Henstock, Lisa C. McNeill, and David R. Tappin, Seafloor morphology of the Sumatran subduction zone: Surface rupture during megathrust earthquakes? Geology, v34, pp485-488, 2006

The data were gathered by HMS Scott, a UK Royal Navy survey vessel, during marine scientific research coordinated by the Joint Environment Directorate of Defence Intelligence. The Royal Navy, British Geological Survey, National Oceanography Centre (Southampton), United Kingdom Hydrographic Office and the Government of Indonesia cooperated on this project.

Link to data source — http://www.noc.soton.ac.uk/gg/sumatra/hms_scott.html

Data set information

During January and February 2005, the Royal Navy survey vessel HMS Scott conducted bathymetric mapping of part of the Sumatra subduction zone. The work concentrated on the southern 450 km of the 2004 rupture (within Indonesian waters) and on the deeper water around the trench and the slope of the accretionary wedge, although some coverage of the Aceh forearc basin was also obtained.

The resultant bathymetric grid produced from the survey data has been included in the GEBCO Grid.

The data were included into the GEBCO grid using the remove-restore procedure.

Annex N.15

Waters off the West Coast of Africa

Included in — version 20141103 of the GEBCO_2014 Grid

Data set coverage — 34° N - 8° N; 18° 30' W - 7° 30' W

Data set provider — Olex AS, Norway

Data source

Olex is a Norwegian company that produces mapping and visualisation software, largely based on data collected from fishing vessels. They have made a sub-sample of their global marine soundings database available to GEBCO. This data set is largely focussed in shallower water areas, mainly in the North Atlantic Ocean region.

Data set information

Data from the Olex data set within a bounding polygon, the extent of the dense Olex data coverage in this area, were used to update the GEBCO grid.
These data were combined with data from the existing GEBCO grid, outside of the polygon region, using an adjustable tension continuous curvature surface gridding algorithm, i.e. 'surface' from Generic Mapping Tools (GMT).

Annex N.16

Northwest European Continental Shelf region

Included in — version 20141103 of the GEBCO_2014 Grid

Data set coverage — 64° N - 45° N; 10° W - 15° 30' E

Data set information

Olex is a Norwegian company that produces mapping and visualisation software, largely based on data collected from fishing vessels. They have made a sub-sample of their global marine soundings database available to GEBCO. This data set is largely focussed in shallower water areas, mainly in the North Atlantic Ocean region.

Data from the Olex data set, for the Northwest European Continental Shelf region, have been used in the development of previous versions of the GEBCO grid. However, the coverage of the Olex data used stopped at 0° E. The method used to include the data in the GEBCO grid also resulted in a line of discontinuity in the data set, see our 'reported bugs' page — http://www.bodc.ac.uk/help_and_hints/errata/gebco/gebco_08.html.

The coverage of the Olex data set has now been extended to — 64° N - 45° N; 10° W - 15° 30' E.

The data were included in the GEBCO grid using the remove-restore procedure.

Annex N.17

South Pacific Ocean, Coral Sea region

Included in — version 20141103 of the GEBCO_2014 Grid

Data set coverage — 187° S to 22° S; 158° E to 162° E

Data set provider — Geoscience Australia (on behalf of the data set originators at the University of Sydney) for data from R/V Southern Surveyor (survey code SS2012_v06) and The Royal Australian Navy, Australian Hydrographic Service for data from hydrographic surveys of the region.

Data set information

At the end of 2012, a scientific cruise (survey code SS2012_v06) led by the University of Sydney in the Coral Sea region of the South Pacific Ocean reported that an island, "Sandy Island", shown in some digital data sets, including the GEBCO_08 Grid, did not exist. Further information can be found on GEBCO's web site.

It is believed that the island has been incorporated into terrain models such as GEBCO via its inclusion in digital coastline data sets.

In order to correct this error in the GEBCO_08 Grid, the scientists who collected the data kindly made it available to GEBCO, via Geoscience Australia. To further help with this update work, the Australian Hydrographic Office provided data from some of their survey data sets for the region.

Using these data sources, this area of the GEBCO_08 Grid has been updated. The update work was carried out by gridding the newly supplied data using GMT's 'surface' gridding algorithm.

Annex N.18

Waters off Chile

Included in — version 20141103 of the GEBCO_2014 Grid

Data set coverage — 18° S to 55° S; 77° W to 67° W

Data set provider — Chilean Navy Oceanographic and Hydrographic Service

Data set information

Data extracted from Electronic Navigation Charts (ENCs) has been provided for waters off Chile to help update the GEBCO Grid. This is as part of an initiative to help improve GEBCO's grids in shallower water regions.

From this data set, over 81,000 soundings were used to update the GEBCO grid. These data were combined with other trackline survey data in the region and gridded using an adjustable tension continuous curvature surface gridding algorithm, i.e. 'surface' from Generic Mapping Tools (GMT).